Technical Memorandum

This technical memorandum details the results of Hydrologic and preliminary Hydraulic investigation for the proposed bridge crossings of the SR 87 Connector over the Blackwater River and Clear Creek.

Santa Rosa County
Florida

Financial Project No.'s:
416748-3-22-01, 416748-3-22-02,
416748-4-22-01, 416748-4-22-02,
And 416748-4-22-90
ETDM No.:12597
Federal Aid Project No.:
SFT1296R, S129348R

January 2013

Prepared For:
Florida Department of Transportation
District Three
Chipley, FL

Prepared by:
The Balmoral Group.
165 Lincoln Avenue
Winter Park, Florida 32789
Phone: 407.629.2185

PROFESSIONAL ENGINEER CERTIFICATION

I hereby certify that I am a registered professional engineer in the State of Florida practicing engineering with **The Balmoral Group** and that I have supervised the preparation of and approve the analysis, findings, opinions, conclusions and technical advice hereby reported for:

PROJECT: Technical Memorandum

SR 87 Connector Proposed Bridge Crossings of Clear Creek and Blackwater River

Financial Project ID: 416748-3-32-01

Santa Rosa County, Florida

The engineering work represented by this document was performed through the following duly authorized engineering business:

The Balmoral Group

165 Lincoln Avenue

Winter Park, Florida 32789

Telephone: (407) 629-2185

Certificate of Authorization No. **26123**

This technical memorandum provides the preliminary results of the Project Design and Environmental (PD&E) investigation into the construction of the proposed SR 87 connector bridges over Clear Creek, and the Blackwater River, in Santa Rosa County. I acknowledge that the procedures and references used to develop the results contained in this report are standard to the professional practice of hydrologic analysis and hydraulic engineering as applied through professional judgment and experience.

Any engineering analysis, documents, conclusions or recommendations relied upon from other professional sources or provided with responsibility by the client are referenced accordingly in the following report.

FLORIDA REGISTERED ENGINEER:

Gregory S. Seidel, P.E.

Name

REGISTRATION NUMBER: FL #47571

SIGNATURE: ______________________________

DATE: __________

Executive Summary

This report forms a Technical Memorandum for the proposed construction of bridges over Clear Creek, and the Blackwater River as part of the SR 87 Connector, in Santa Rosa County, Florida. This report was conducted in a 'desktop' format, which indicates that neither detailed field investigation, nor detailed hydraulic bridge design has taken place, and conclusions should be interpreted within this context. This report forms the basis of a more detailed Bridge Hydraulics Report that should take place prior to design of either of the SR 87 connector bridges.

Hydrologic analysis of the basins draining to the location of the two proposed bridges was undertaken and verified against previously published investigations. The final adopted peak discharges for the 50 year ARI (Average Recurrence Interval) flood are shown in **Table ES1** below.

Table ES1: Summary of Design Peak 50 year ARI Flows at the proposed bridge crossings of the SR 87 Connector

SR 87 Bridge Crossing	ARI	Final Peak Streamflow (cfs)
Blackwater River	50	71,400
Clear Creek	50	5,640

Preliminary investigations were completed for this report determine that the bridge to span Clear Creek should have a minimum width of approximately 180 feet to meet hydraulic criteria, however due to the parallel alignment of the channel at the position of the proposed bridge, the opening width may have to be increased or another management method incorporated. The bridge is to have a low chord no lower than 19.17 feet NAVD with the minimum opening width.

The preliminary proposed bridge to span Blackwater River should have a length of 5,560 feet, and have a low chord no lower than 21 feet NAVD over the river. A minimum low chord of 27.70 feet NAVD is required to span the Blackwater Heritage State Trail. The length and low chord specification will ensure that the proposed bridges do not adversely impact the flood stages for the 100 year ARI flood by more than 1 foot, achieve environmental elements and meet minimum requirements for clear span over the Blackwater Heritage State Trail and Pat Brown Road. The preliminary design stages for the 50 year ARI Flood are shown below in Table ES2 for both proposed bridge crossing locations.

Table ES2: Summary of Preliminary Design Peak 50 year ARI Stages at the proposed bridge crossings of the SR 87 Connector

SR 87 Bridge Crossing	ARI	Peak Stages with No Bridge (feet NAVD)	Peak Stages with Proposed Bridge (feet NAVD)	Minimum bridge low chord elevation (feet NAVD)	Recommended Bridge Length (feet)
Blackwater River	50	18.00	<19.00	21.00 over river and floodplain and 27.70 over the Blackwater Heritage State Trail	5,560
Clear Creek	50	15.95	16.95	18.95	180

Clear Creek has shown channel variation over the last 50 years. The channel banks should be stabilized adjacent to the roadway within the right-of-way using rubble rip-rap.

General and Aggradation/Degradation Scour was considered and it was found that there is no indication of long term bed elevation shift, nor lateral movement for Blackwater River at the location of the proposed bridge. Given the large peak flow rate and sandy soils at the proposed bridge location, a detailed 2-D flow model is recommended to be completed during final design to better quantify peak stages and scour depths.

TABLE OF CONTENTS

APPENDICIES

LIST OF FIGURES (Appendix A)

LIST OF PLATES

LIST OF TABLES

1. General Information

1.1. Introduction

The Florida Department of Transportation has proposed the construction of an additional section of SR 87 to better facilitate vehicular movement in the area (including freight movement) which currently must use a portion of US 90. The construction will also serve as a more direct hurricane evacuation route from coastal areas into northern areas, including Alabama. Additionally, the new segment of SR 87 will reduce the vehicular travel currently required to pass through the nearby town of Milton.

The construction of this new segment of SR 87 will require two new bridges to be constructed, one of which will need to cross the Blackwater River, and the second, Clear Creek, a tributary of Blackwater River. This report aims to provide details on the current hydrologic conditions at the site of both proposed bridge crossings and provide preliminary requirements for bridge length and low chord elevation, evaluate environmental factors that exist, as well as carry out lateral and long term aggregation/degradation analysis, to ensure an appropriate and environmentally sensitive outcome is achieved.

1.2. Project Location and Datum

The locations of the proposed bridges over Blackwater River and Clear Creek are located approximately 4 miles and 3 miles, respectively, North-East of the city of Milton, within the Santa Rosa County, Florida. The proposed Clear Creek Bridge is located in Section 24, Township 2 and Range 28, and the proposed Blackwater River Bridge is situated in Sections 19 and 30 of Township 2 and Range 27. The locations of both bridges are shown in **Figure 1** and **Figure 3** enclosed in **Appendix A**. The site of the Clear Creek Bridge is approximately 1.4 miles upstream of the confluence with Blackwater River, which then drains into Blackwater Bay. The location of the proposed bridge crossing of Blackwater Creek is approximately 2.4 miles upstream from the confluence of Clear Creek and 11 miles upstream from Blackwater Bay.

This project uses the North American Vertical Datum of 1988 *(NAVD88)*, and the horizontal datum for the project is Florida State Plane *(NAD 1983)*, Northern Zone.

1.3. Purpose of this Technical Memorandum

The primary purpose of this technical memorandum is to review, and compare all current work that has been conducted in relation to the hydrologic and hydraulic investigations of the sites, as well as provide results of an independent investigation into the hydrology and preliminary hydraulics of the two proposed bridge crossings.

This Technical Memorandum will provide critical hydrologic and hydraulic information that can be used to assist in the design of the SR 87 bridge crossings of Blackwater River and Clear Creek. In particular, it will establish design peak discharges at the two sites, and provide design stage estimates to allow the minimum bridge low chord to be established and utilized in the preliminary design plans.

1.4. EXISTING DRAINAGE OVERVIEW

Clear Creek, at the site of the proposed bridge, drains an area of approximately 23 square miles, and Blackwater River an area of 704 square miles. **Plate 1** below, as well as **Figure 2** in **Appendix A** shows the basins for both proposed bridge crossings.

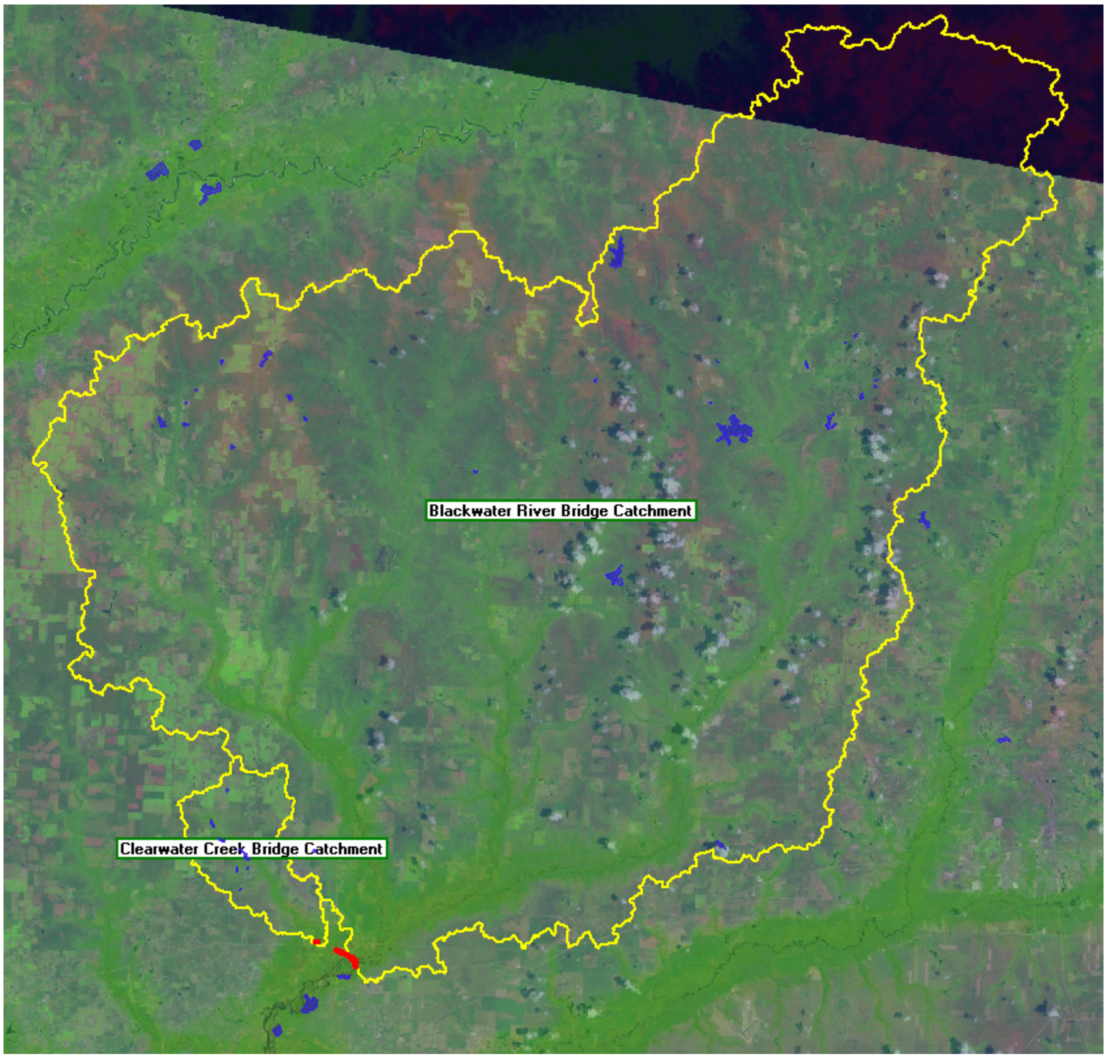


Plate 1: Location and Basins for the two proposed bridge crossings

Clear Creek generally drains from northwest to southeast, and Blackwater River drains from northeast to southwest and meanders considerably in some sections; however, the river has numerous tributaries, such as Big Coldwater Creek.

As shown in **Plate 2 and 3** below, the area around both proposed bridge crossing sites is undeveloped and comprises dense vegetation and tree coverage. The trees and ground cover help to maintain the integrity of the natural channel during low flows and floods. It should be noted, that an area adjacent to both bridges has been cleared, and contains short shrubs (as seen in **Plate 2**), due to a power line easement.

Plate 2: Common vegetation in the clearing adjacent to the proposed Clear Creek bridge site, and the site from the air.

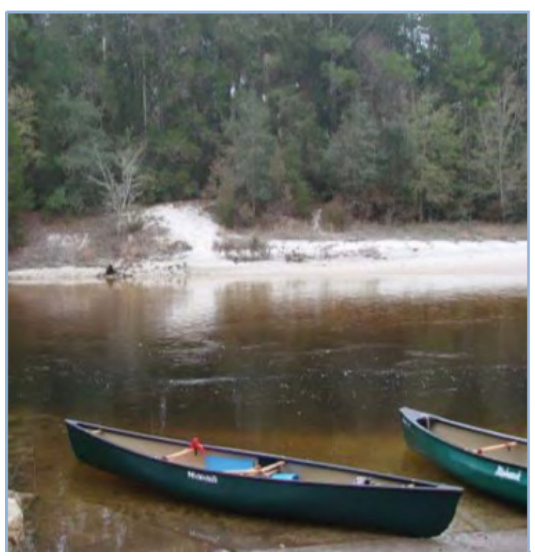


Plate 3: Proposed Bridge location over Blackwater River, and the normal vessels traversing the river.

1.5. TAILWATER

1.5.1. Clear Creek

Gage stations were investigated to provide a suitable tailwater elevation; however, no gages exist at the proposed site of the bridge, and the Clear Creek Gage (USGS 02370550, Clear Creek near Milton, FL) has only intermittent stage data from between 1983 and 1998, and hence does not include sufficient data to determine the design flood peak stages.

As a result, flood behavior in the vicinity of the proposed SR 87 connector bridge crossing over Clear Creek was defined using a HEC-RAS hydraulic computer model of Clear Creek that was developed specifically for this investigation. In order to ensure that flood behavior in the vicinity of the bridge is being reliably defined by the HEC-RAS model, it was necessary to establish reliable tailwater estimates.

As the confluence of Clear Creek with Blackwater River is located only 1.4 miles downstream of the proposed bridge crossing, it was considered that backwater impacts from Blackwater River would impact stages along Clear Creek. As a result, tailwater elevations published in Figure 01P (enclosed in **Appendix E**) by FEMA in the 1996 Flood Insurance Study were utilized to set the tailwater in the HEC-RAS model. These elevations were 13 feet NAVD for the 50 year ARI (Average Recurrence Interval) flood and 17 feet in the 100year ARI flood.

It should be noted that this is a conservative approach to tailwater derivation, as flooding in different sized basins will peak at different times. As the Clear Creek Basin is significantly smaller than the Blackwater River Basin, the relative timing of peak flows will undoubtedly vary, and hence a 50 year ARI rainfall event in the Clear Creek Basin, may only yield a 20 year ARI flood peak at the confluence of the Blackwater River. The opposite is also possible; however, as lower flows would be moving from the Clear Creek Basin at the time of this larger tailwater peak, it is most likely that this would not form the critical scenario.

1.5.2. Blackwater River

Gage stations were investigated to provide a suitable tailwater elevation; however, as previously stated, no gages exist at the proposed site of the bridge, and there are no gages downstream, nor upstream for a significant distance of the proposed site on the Blackwater River. Similarly to the tailwater for Clear Creek, details are available from the 1996 FEMA Flood Insurance Study regarding flood stages along Blackwater River, including a transect at the approximate location of the proposed bridge crossing.

The FEMA stages were evaluated for appropriateness of use. It was found that the stages were estimated using a USACE HEC-2 Model developed using surveyed field data. The results presented in the study are considered to provide a reliable representation of design stages along the river for planning purposes. As a result, stages can be read from Figure 01P (enclosed in **Appendix E**) in the study and utilized to estimate the required bridge clearance. The stages will be adopted as 18 feet NAVD for the 50 year ARI flood, and 20 feet for the 100 year ARI flood.

1.6. WETLAND AND FLOODPLAIN IMPACTS AND MITIGATION

As the two bridges will be constructed on sites that do not currently have any structures, impacts on the wetlands and forested areas will occur. Mitigation will be required to account for these impacts. Remediation techniques that have been outlined for possible use for these bridges include a mitigation bank credit purchase, or a Senate Bill Mitigation; however, the form of mitigation will be determined during permitting by the Interagency Review Team (IRT).

Section 60.3(c) (10) of Title 44 of the code of Federal Regulations requires that the proposed bridge not increase peak 100 year water surface elevations by more than 1 foot relative to the natural (i.e.: no bridge) condition at any location. The preliminary hydraulic analysis for the proposed Clear Creek Bridge in Section 3.1.5 demonstrates that the proposed bridge satisfies this criterion. The proposed bridge crossing of Blackwater River is shown to satisfy this criterion by spanning the FEMA delegated Zone AE regulated floodway as well as the northern floodplain.

1.7. HYDRAULIC DESIGN CRITERIA

The Florida Department of Transportation (FDOT) Drainage Manual (2012) stipulates a range of criteria that must be satisfied for any new or replacement structures. A summary of these criteria is provided below for the SR 87 Connector Bridges:

Design Frequency = 50 year (projected 20 year ADT greater than 1,500 and required for emergency access);

Vertical clearance = 2 feet above peak design flood stage for drift clearance / 6 feet above normal high water for navigation clearance (not applicable as both Clear Creek and Blackwater River are not navigatable by vessel other than canoe/kayak)

The ten feet berm to facilitate construction, reduce scour potential, and provide for abutment stability shall be provided between the top edge of main channel and the toe of spill through abutments;

Scour protection must be designed to withstand the worst case scour condition up to and including the 100 year event (not covered in this investigation); and,

Scour must be checked during the worst case scour conditions up to and including the 500 year event to ensure structural integrity is maintained (not covered in this investigation).

2 Hydrologic Analysis

2.1 General

In order to be able to reliably define flood behavior in the vicinity of the proposed SR 87 connector bridges over both Clear Creek and Blackwater River, it is first necessary to establish reliable design discharge estimates. The following sections describe the hydrologic procedures that were employed to derive the design discharges.

2.2 Drainage Basin

2.2.1. Clear Creek

Clear Creek, at the site of the proposed SR 87 connector bridge, drains an area of approximately 23 square miles. The basin varies in elevation from 240 feet NAVD in the upper basin to 10 feet NAVD at the site of the proposed bridge. There are two major storage dams located in the basin; however the land use within the basin is predominantly rural, agricultural and natural wooded area. The basin is presented in **Figure 2** in **Appendix A**.

Clear Creek drains into the Blackwater River. As the Blackwater River is potentially liable to tidal influence (due to the channel invert being below sea level), it was considered necessary to investigate whether there was the potential for Clear Creek to also be tidally influenced. USGS gage 02370550 (Clear Creek near Milton FL) is located just downstream of the proposed bridge crossing of Clear Creek, and analysis of the minimum water level yielded a stage of 3.84 feet NAVD, with a channel invert at the proposed bridge site approximately equal to this, in which is well above any possible normal tidal influence, and as a result, it was determined that the site is not subject to tidal flows *(i.e.: freshwater flows in one direction only)*.

2.2.2. Blackwater River

The Blackwater River at the proposed bridge site drains an area of approximately 704 square miles. The basin varies in elevation from 280 feet NAVD to 3 feet NAVD at the location of the proposed bridge site. There exist a number of large dams and wetland areas within the basin; however the land use is predominantly rural, agricultural and has a large proportion of naturally wooded area. The basin is presented in **Figure 2** and an Aerial view is shown in **Figure 7**. Additionally, the basin headwaters, found in Southern Alabama, flow through Okaloosa County and drain 56.6 miles into the Blackwater Bay, approximately 11 miles downstream of the proposed bridge site.

In an effort to quantify if the proposed bridge location would be tidally influenced, an investigation into the tidal levels within Pensacola Bay (the eventual receiving body for flows from Blackwater River) was undertaken. This investigation utilized data from Station id 8729840, located at Pensacola, Pensacola Bay, and provided 19 years of data, which was considered appropriate for this investigation. The gage location, and project vicinity can be seen in **Plate 4**.

Plate 4: Location of Pensacola Bay Tide Gage and Project Area.

The Mean Higher High Water Level (MHHWL) was extracted from the NOAA National Ocean Service records and found to be 1.327 feet NAVD88 (NOAA, 2012). As the elevation of the channel bed at the proposed site of the Blackwater River Bridge is -11feet NAVD88, well below sea level, it was considered that there is the possibility of a tidal influence at the Blackwater River Bridge. As such, further investigation was undertaken, including derivation of the minimum basin flow that could be expected at the proposed bridge site.

As previously stated, no gage exists at the site, however, the gage upstream from the bridge site along the Blackwater River could be used to estimate constant low flows. It was found that a minimum mean annual flow of 130cfs was experienced. Factoring this up by the catchment area ratio (3.5x) of the gaged site to the proposed bridge site, gives a mean annual flow of 455cfs. It was considered that a flow of this magnitude would provide a sufficiently high energy grade line to prevent saltwater intrusion up the river system to the proposed bridge site. Additionally, as the proposed bridge site is located 11 miles upstream of Blackwater Bay, dampening effects on the tide would be significant and hence maintain a constant downstream flow of freshwater at the proposed bridge site, and the site is not considered to be subject to tidal flows *(i.e.: freshwater flows in one direction only).*

It must be noted that the above conclusion is only valid for normal tide situations, and extremely high or low tides may alter the regime. The Pensacola Bay gage has recorded a maximum tide of 8.771 feet NAVD, and a minimum tide of -2.528 feet NAVD, which indicates that extreme tides can occur, most likely due to hurricane surges, and should be considered in future investigations. (Data extracted from http://tidesandcurrents.noaa.gov/data_menu.shtml?stn=8729840 Pensacola, FL&type=Bench Mark Sheets)

2.3 History of Flooding

Both the proposed bridge crossings of Clear Creek and Blackwater River are located in un-developed rural areas and hence there is no documentation of historic flooding in the direct vicinity of the proposed bridges. Gages located on the watercourses are either too far from, or have a very short period of record to be of sufficient use in determining flood behavior at the location of the proposed bridges.

Additionally, FDOT Maintenance has no reoccurring flooding issues within the limits of this project. There has been some record of major flooding during large storms and hurricanes in the vicinity of the Blackwater River Bridge. It is known from previous investigations and discussion with Public Works Officers that the power easement, located adjacent to the proposed Blackwater River Bridge crossing location, and Pat Brown Road, repeatedly floods to the 100 year flood zone line.

An investigation of storm surge risk, carried out from the National Oceanic and Atmospheric Administration's (NOAA's) Storm Surge Interactive Risk Maps resulted in an acknowledgement of a risk of storm surges at the proposed location of the Blackwater River Bridge. The storm surge elevations associated with a Category 3 through 5 hurricane are between 2 and 10 feet, and a Category 1 hurricane had the storm surge potential of 2 feet just downstream of the bridge location, and as such, there exists the possibility of storm surges in a hurricane of any category. The location of the proposed Clear Creek Bridge did not yield any risk of hurricane surge.

2.4 Previous Studies

A number of previous studies have been carried out in the vicinity of the two proposed bridge sites. The major reports are listed below and a brief description follows:

- FEMA Flood Insurance Study, FEMA, 1996
- Draft BHR Blackwater River, Metric Engineering, 2012
- Draft BHR Clear Creek, Metric Engineering, 2012
- BHR FDOT SR 87 Over Clear Creek, Project Development and Environmental Phase, Volkert Inc, August 2010

FEMA Flood Insurance Study

Although not done to investigate the construction of the two proposed bridges, the FEMA Flood Insurance Study provides an insight into the flooding behavior that occurs within both Blackwater River and Clear Creek. It provides a guide to the peak flows that could be expected, appropriate stages to adopt in hydraulic models and allow verification of results. The FEMA FIRM for Blackwater River is provided in **Figure 4** enclosed in **Appendix A**.

Draft Bridge Hydraulics Report, Blackwater River

The Blackwater River BHR was prepared by Metric Engineering on behalf of the FDOT to investigate the feasibility, design requirements, and environmental considerations pertaining to the construction of the new bridge over the Blackwater River. Data available from this report includes a hydrologic and hydraulic assessment of the proposed site, and design of the bridge, including impacts and remediation plans for any adverse impacts and coordination with local agencies.

Draft Bridge Hydraulics Report, Clear Creek

The Clear Creek BHR was prepared by Metric Engineering on behalf of the FDOT to investigate the feasibility, design requirements, and environmental considerations pertaining to the construction of new bridges over the Blackwater River, and Clear Creek, respectively. Data available from this report includes a hydrologic and hydraulic assessment of the proposed site, and design of the bridge, including impacts and remediation plans for any adverse impacts and coordination with local agencies.

Bridge Hydraulics Report, FDOT SR 87 Over Clear Creek

This Bridge Hydraulic Report was prepared for the FDOT in the Project Development and Environmental (PD&E) stage for the replacement of the existing SR 87 Bridge over Clear Creek and recommends replacement bridge specifications, as well as covers some hydrology and hydraulics of the Clear Creek basin draining to the location. Comparisons between hydrologic conditions and expected scour can be carried out with data presented in this report.

2.5 Peak Flow Analysis

2.5.1. Flood Frequency Analysis

In order to generate reliable design stages for the proposed SR 87 bridges, it was necessary to compute reliable peak flow estimates for the Blackwater River and Clear Creek at the site of the proposed bridges.

The 2012 FDOT Drainage Manual suggests that design discharge estimates be determined utilizing a flood frequency analysis of gages with a suitable length of stream-flow record. As no stream gage is located at the exact location of the proposed bridges, a search for nearby gages was undertaken, and two gages within the basin were identified. These gages are namely USGS 02370500 – Big Coldwater Creek near Milton FL, and USGS 02370000 – Blackwater River near Baker, FL. Although other gages are also located within the basin, the period of record and geographic location within the basin were deemed inappropriate to supply meaningful stream flow records over an appropriate period of time.

A Flood Frequency Analysis was undertaken using the peak streamflow records for these two gages utilizing the USGS PeakFQ software and using input data gained from the USGS National Water Information System. The PeakFQ software uses the methods established by the U.S. Water Resources Council Bulletin 17A (U.S. Water Resources Council, 1977).

The basin areas, slope, and proportion of lakes for the basins of the two before-mentioned gages were derived for input into the National Streamflow Statistics (NSS) program, in which utilizes the USGS regression equations to provide an estimate of design peak stream flow for catchments throughout the United States.

Table 1 below provides the details of the two before-mentioned gages including the period of record, and basin area. **Plate 5** also identifies their location within the Blackwater River basin. The required input parameters were generated by using the CatchmentSIM software, and validated against basin areas stated by the USGS Water Resources Stream Site description.

Table 1 – gages with appropriate data for use in a flood frequency analysis.

Gage ID	Watercourse	Period of Record	Basin Area (sq.miles)	Slope (ft/mile)	Lakes (%)
02370500	Big Coldwater Creek	1939-2011	238	6.84	0.09
02370000	Blackwater River	1951-2011	206	7.92	0.34

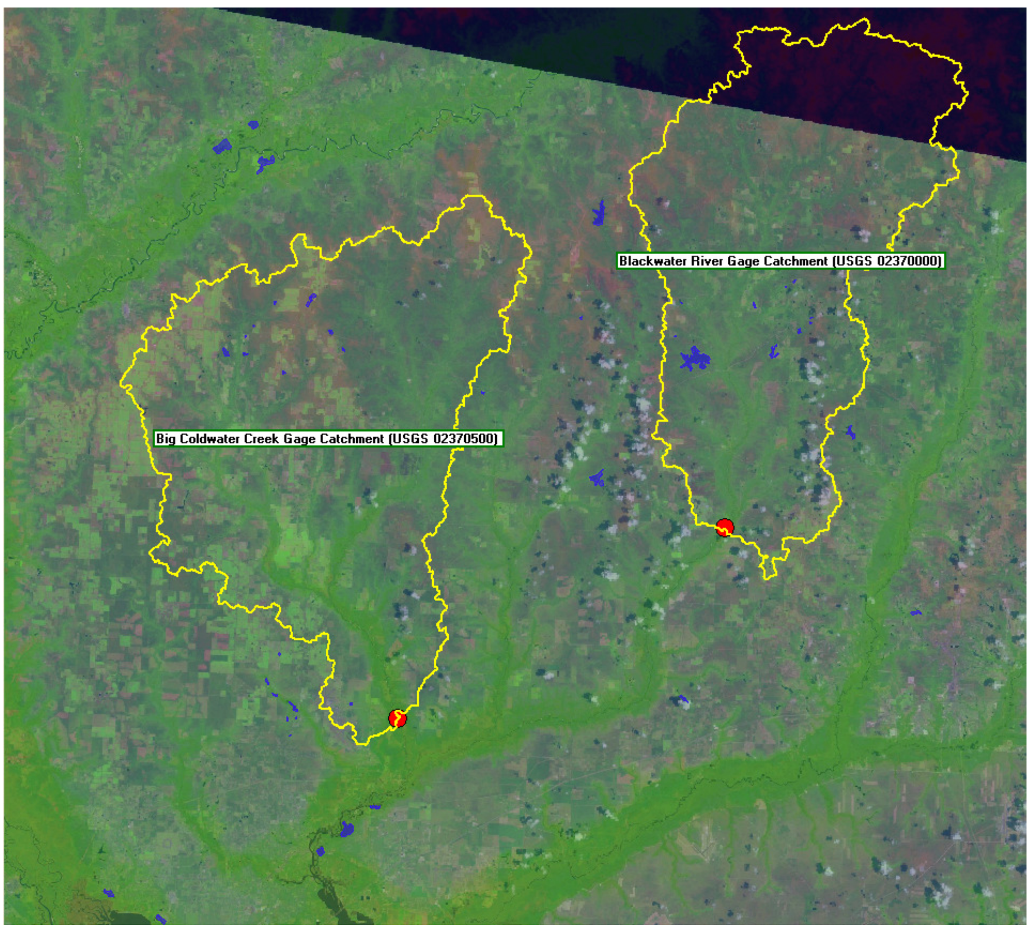


Plate 5: Location and basins for the gages within the Blackwater River basin

The aim of utilizing a Flood Frequency Analysis (FFA) of these upstream gages was initially to carry out the NSS Rural Flood-Probability Estimating Technique of utilizing a weighting for ungaged sites on gaged streams. It was however, determined that this procedure cannot be utilized as the drainage area for both of the gaging stations was less than half the drainage area for the ungaged site (effective range for this method is between 0.5 and 1.5 times the gaged drainage area).

As such, the USGS (NSS v6 2012) regression equations were utilized to estimate peak design flows at both of the gaging site locations. This aimed to verify the suitability of the NSS discharge estimates at the gage locations and, therefore, to infer a level of confidence with the NSS discharge estimates at the bridge locations. As shown in **Table 2**, there is a significant disparity between peak FFA design flows and design flows predicted by the NSS regression analysis. **Table 2** shows that the NSS regression analysis typically produced peak discharge estimates that were 40% lower than the corresponding FFA peak discharge estimate.

Table 2 – Flood Frequency Analysis and USGS regression results and comparison

	ARI	FFA peak streamflow (cfs)	Regression peak streamflow (cfs)	Calibrated regression peak streamflow (cfs)
Big Coldwater Creek				
	5	11,800	9,060	12,100
	10	17,570	12,900	17,900
	25	27,420	19,200	27,400
	50	36,960	25,200	36,700
	100	48,720	31,800	47,300
	200	63,120	39,700	59,900
	500	87,110	51,900	80,300
Blackwater River				
	5	8,970	7,930	10,100
	10	13,330	11,200	14,700
	25	20,640	16,600	22,200
	50	27,610	21,600	29,500
	100	36,070	27,100	37,700
	200	46,280	33,600	47,300
	500	62,980	43,700	62,600

As a result of this variation, adjustment of the input parameters was undertaken by refining the basin slope and % lakes until the peak design discharge estimates generated by the regression analysis agreed (as close as possible) with the design discharge estimates using the flood frequency analysis. Factors of the originally derived parameters for both gages were then calculated, and averaged to provide final factors of 1.9 for the slope parameter, and 1.6 for the % lakes parameter. These factors were the applied to the raw regression analysis discharges to gain ‘calibrated’ discharge estimates that closely agreed with discharges gained from the flood frequency analysis.

The outcomes of the application of these adjustment factors are shown in **Table 2** above. Derivation of the factors and a summary of the peak flows for all locations is shown in **Appendix B**.

The results of the above process were then compared to a 2006 study by the USGS. The USGS study was completed to determine procedures for estimating flood magnitudes and quantities at ungaged sites. As a result, the peak flows attained through the process outlined above were compared to the results published in the USGS report, and a comparison is shown below in **Table 3**.

The design flows presented below in **Table 3** show that some variation is occurring between the 2006 USGS study and the ‘calibrated’ NSS regression peak streamflow. Differences can be accounted for by the fact that the analysis done for this project includes an additional 5 years of data, including data from 2009, in which represents a significant flood event. Additionally, only significant water bodies were considered as lakes in order to maintain a conservative approach to determining peak flows in significant flood events.

Table 3: USGS Magnitude and Frequency of Floods for Rural Streams in Florida Study comparison to derived peak discharges

	ARI	USGS peak streamflow (cfs)	Calibrated NSS regression peak streamflow (cfs)
Big Coldwater Creek			
	5	11,300	12,100
	10	16,500	17,900
	25	24,800	27,400
	50	32,600	36,700
	100	41,600	47,300
	200	52,300	59,900
	500	69,400	80,300
Blackwater River			
	5	8680	10,100
	10	12,500	14,700
	25	18,400	22,200
	50	23,600	29,500
	100	29,500	37,700
	200	36,100	47,300
	500	46,400	62,600

2.5.2. Peak Design Flows

The USGS (NSS v6 2012) regression analysis was then carried out at the site of the proposed bridges, using parameters gained from basin analysis using CatchmentSIM. These parameters are shown below in **Table 4** for both bridge crossings of Blackwater River, and Clear Creek.

Table 4: Regression analysis inputs for the two proposed bridge crossings

SR 87 Bridge	Basin Area	Slope	Lakes (%)
Blackwater River	703.77	4.75	0.2
Clear Creek	22.88	15.31	0.48

As the basins draining to these two bridge crossings were within the same geographic vicinity of the previously analyzed gage basins, it was decided that the previously determined slope and % lakes 'calibration' factors could be appropriately applied to the two bridge crossings to gain peak streamflow values. The results of this application are shown below in **Table 5**, and **Appendix B** contains the derivation calculations.

Table 5: Results of regression analysis and final flow estimates for the two bridge sites.

SR 87 Bridge Crossing	ARI	Raw Regression peak stream flow (cfs)	Calibrated Regression peak stream flow (cfs)
Blackwater River			
	5	18,300	24,000
	10	25,900	34,900
	25	38,500	53,300
	50	50,400	71,400
	100	64,000	92,200
	200	80,400	117,000
	500	106,000	158,000
Clear Creek			
	5	1,630	2,040
	10	2,300	2,940
	25	3,320	4,330
	50	4,250	5,640
	100	5,220	7,020
	200	6,310	8,570
	500	7,950	11,000

To validate the peak stream flows, and the applied factors, a further NSS regression analysis was conducted for the basin draining to the ‘Louisville and Nashville Railroad’ crossing of the Blackwater River. This was chosen as the 1996 FEMA Flood Insurance Study (FEMA, 1996) has published peak flows to this location and could hence allow a comparison at this location. Again, the CatchmentSIM regression derived slope and % lakes parameters were multiplied by the previously determined factors, and ‘calibrated’ flows computed. **Table 6** below provides details of the parameters input for this regression analysis as well as a comparison of these ‘calibrated’ flows with those published in the FEMA Flood Insurance Study.

Table 6: regression analysis inputs and results for the Louisville and Nashville Railroad crossing of Blackwater River

Just downstream of the Louisville and Nashville Railroad	FEMA derived parameters	CatchmentSIM derived parameters
Basin Area (sq.miles)	747.4	748.9
Slope (ft/mile)		4.69
Lakes (%)		0.23
	FEMA peak streamflow (cfs)	Calibrated NSS regression peak streamflow (cfs)
5		24,700
10	35,900	36,000
25		54,900
50	69,900	73,400
100	89,900	94,700
200		121,000
500	152,900	162,000

As can be seen from **Table 6**, a close replication of the FEMA peak streamflow has been attained, which allows a greater confidence in the use of the adjustment factors. Therefore; flows obtained for both the Blackwater River and Clear Creek bridge crossing sites are considered appropriate for use in design.

A further check was undertaken by comparing the FEMA Flood Insurance Rate Map (FIRM) transects at the location of the bridge to the above calculated streamflow. This was conducted by multiplying the cross-sectional area of the transect by the average velocity through the transect (extracted from the FEMA Flood Insurance Study) to gain a 100 year peak streamflow value.

This procedure can only be used as a general comparison due to the use of the average velocity to compute the streamflow, and the fact that the transect area is provided only for the portion of flow that falls within the FEMA criteria of Floodway (obstruction would cause an increase in stage by more than 1 foot). As the floodway carries the vast majority of event streamflow, the comparisons between computed flows should be significantly close, however, stream flow generated by this method should underestimate slightly the total streamflow across the transect as a small proportion will be conveyed in the flood fringe .

The comparison is shown below in **Table 7**, and indicates a fairly close reproduction of the FEMA transect values at the exact location of the proposed bridge crossing on Blackwater River. As can be seen from the results, the FEMA streamflow is slightly below that calculated previously in this study, which as explained, is expected when considering that the FEMA transect area and velocity excludes the conveyance in the flood fringe.

Table 7: Regression flow comparison against FEMA transect ‘L’ flow (from Flood Insurance Rate Map, Panel 340 of 657)

Floodway section area (Sq.ft)	52105	
Mean Velocity (ft/second)	1.7	
	FEMA peak streamflow (cfs)	Calibrated NSS regression peak streamflow (cfs)
100 year ARI	88,579	92,200

No such transect exists at the site of the proposed Clear Creek bridge crossing, so no comparison is able to occur.

3. Hydraulic Analysis

3.1 Clear Creek

3.1.1. General

A one dimensional steady state HEC-RAS hydraulic model was created for Clear Creek in the vicinity of the proposed bridge. The cross sections were created by sampling a NOAA lidar derived DEM and allowed numerous cross sections to be extracted. These cross sections extended about 600 feet upstream and 1200 feet downstream of the proposed site (measured along the main channel). NAVD 88 datum was utilized, along with the Energy Equation for the modeling approach. The positions of the HEC-RAS cross-sections are shown in **Figure 6** in **Appendix A**, and **Appendix C** provides details of the HEC-RAS Project and Outputs.

The intention of this HEC-RAS model was to try and determine an appropriate preliminary bridge opening length and low member elevation. These parameters would also need to meet the criteria of the NWFWMD (North West Florida Water Management District), that being, an increase in stages upstream of the bridge no greater than 1 foot in the 100 year ARI flood.

3.1.2. DEM

The cross sections utilized in the hydraulic model were extracted from a DEM for the area around the proposed site of the Clear Creek Bridge, and was supplemented with survey data from a previous investigation of Clear Creek. The DEM was generated by interpolating between lidar ground strikes and then creating a 2 foot raster grid representation of the ground surface. The lidar was sourced from the National Oceanic and Atmospheric Administration (NOAA), however, as lidar has difficulty providing elevation data in areas of dense vegetation, or within water bodies, lidar point data in vegetated areas are sparser than in open/clear areas. Additionally, no creek invert elevations were able to be extracted from the lidar, and were instead interpolated from survey from previous studies in the general vicinity of the proposed bridge. (Bridge Hydraulics Report, FDOT ST87 over Clear Creek, Volkert INC, August 2010). This data was deemed acceptable for this preliminary analysis.

3.1.3. Mannings Roughness

The Mannings ‘n’ values used in the HEC-RAS model cross-sections were determined using the FHWA’s (Federal Highway Administration) “Guide for Selecting Manning’s Roughness Coefficients for Natural Channels and Flood Plains” (FHWA, 1984). Appropriate parameters were selected based on examination of aerial photography and a limited number of field photographs, and hence are limited in accuracy to the attributes visible in this photography. The adopted Mannings ‘n’ values are shown below in **Table 8**, and full computations are presented in **Appendix C**.

Table 8: Mannings 'n' values adopted in the HEC-RAS Model (values computated using the FHWA's "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains")

Surface	Adopted Mannings 'n'
Creek channel	0.04
Flood Plain	0.10

3.1.4. Boundary Conditions

Downstream boundary conditions were investigated from multiple sources that were considered likely to impact stages at the proposed bridge crossing. The first of these was the potential for backwater impacts from the Blackwater River. This was investigated by analysis of FEMA Flood Insurance Rate Maps (FIRM) and Figure 01P in the 2006 FEMA study, in which shows that at the confluence of the Clear Creek and Blackwater River, a stage of 13 feet is reached in the 50 year ARI flood, and 17 feet in the 100 year ARI flood. This was utilized as the tailwater in the HEC-RAS model. As previously discussed, this application is a conservative approach as the relative timing between peaks of such largely different basin areas will vary and lead to lower flows from the Clear Creek Basin at the time of the adopted downstream stages on the Blackwater River.

Additionally, a downstream bridge crossing at the Munson Hwy was investigated for any hydraulic backwater impact on the proposed bridge. As no details of this bridge were known, a 'desktop' approach of analysis was conducted to attempt to quantify the potential impacts of this bridge. This approach required the modeling of the bridge as a 180 feet opening, and routing the previously determined flows through it. The impact on upstream stages was quantified, and then added to the backwater effects within Clear Creek. The distance downstream and creek bed slope were then also considered and it was found that this bridge had a small impact on stages at the location of the proposed SR 87 bridge crossing, and these were included in the design model as a known water surface. As this is a Project Development and Environmental (PD&E) phase technical memorandum, detailed analysis of this interaction has not taken place, and hence the Munson Highway bridge should be carefully considered in any further investigations.

Additionally, two further downstream bridges (Pat Brown Rd and Blackwater Heritage State Trail) were again considered for their possible impact on stages at the site of the proposed bridge, however this was quickly ruled out due to the backwater impacts of Blackwater River which would inundate the vicinity of these two downstream bridges, and hence control the water surface elevation in these lower areas of Clear Creek. A more rigorous analysis should be completed in the final design.

3.1.5. Preliminary Design Flood Stages

The process involved in the preliminary design of the SR 87 Bridge over Clear Creek required the modeling of pre-construction conditions along the creek alignment to gain a baseline stage during the 50 year and 100 year ARI flood events. The flows previously described were utilized in the developed HEC-RAS model, and yielded stages of 15.95 feet in the 50 year, and 18.42 feet in the 100 year event. The calculated stage at the proposed bridge site is similar to the FIRM 100 year stage shown on the FIRM map, that being ~18 feet. (It should be noted that the FIRM stages are a whole number rounding and hence allow for up to 0.5 feet variation in stage values).

Next, a post construction scenario was modeled, and consisted of the addition of a bridge in the position of the proposed bridge alignment. Various bridge opening lengths were evaluated and the stages gained compared to the baseline scenario in an attempt to minimize the bridge opening, but still meet the requirements of the NWFWMD in relation to the maximum allowable stage increase due to construction (max 1 foot increase in the 100 year ARI flood).

The outcome of this analysis led to the adoption of a 180 feet bridge, with 1:2 sloping abutments to span the major Clear Creek alignment. The upstream stages that are produced with the above described bridge characteristics are 16.95 feet in the 50 year event, and 19.16 in the 100 year event. This bridge opening size ensures that less than a 1 foot increase in stage in the 100 year event occurs upstream of the proposed bridge, however, as this was only a preliminary design, no bridge piers were included, and hence, upstream stages may increase slightly. As a result, the preliminary minimum low chord should be set at an elevation of 18.95 feet NAVD. The proposed bridge location and length can be seen on **Figure 10** in **Appendix A**.

It is important to note that the Clear Creek channel at the site of the proposed bridge site moves in an east to west direction along the proposed alignment of the roadway, and this can be seen in **Figure 6**. This east to west movement of the channel extends for a distance of over 400 feet, and the required design bridge length is 180 feet (for stage increase criteria). As such, the 180 foot opening length should be seen as the minimum bridge opening criteria, and a number of options exist to manage the potential problems associated with the current creek alignment.

Firstly, a re-alignment of the creek channel could be undertaken, and a skew angle of piers and abutment would be required in order for effective flow through the bridge opening. A second alternative would be to extend the bridge opening to a sufficient width to account for any future channel lateral movement, as well as the current alignment of the creek. The described options should be considered in the final design as well as any other viable alternatives to ensure an optimum solution is gained.

3.2 BLACKWATER RIVER

The proposed bridge over Blackwater River is located in a position which has received greater attention from regulatory agencies in relation to expected flooding behavior. Additionally, due to the meandering nature of the Blackwater River upstream and downstream of the proposed bridge site, it was decided that a HEC-RAS model would not be appropriate to model the behavior that may occur within the river and the adjacent floodplains. It would be recommended that any further investigations into flood behavior in the vicinity of the proposed bridge utilize a 2D model.

As such, the design of the proposed bridge length and low chord elevation took place utilizing already derived data. However, there were still many factors requiring consideration in which will impact both the length and minimum height of the bridge deck. A summary of these major factors are described below;

- The ability for watercraft to pass under the bridge and navigate the river. It was determined by prior field investigation that the only vessel navigation that occurs is canoes/kayaks, some small motorized flat bottom boats, and personal watercraft and hence requires a minimum horizontal clearance of 10 feet and a minimum vertical clearance of six feet above the mean high water (MHW) to accommodate these vessels.

- The Blackwater River has been studied by FEMA using a USACE HEC-2 step-backwater model and the results are presented on FIRM map 0340G. These results show that a regulated floodway exists as a "Floodway Area" with a zone categorization of AE, indicating that it will be inundated by the 100 year ARI flood. As a result, the proposed bridge will need to be sufficiently sized to span this floodway to ensure flood stage increases upstream of the proposed bridge do not exceed 1 foot.

- The bridge will also be required to provide an overpass route past Pat Brown Road, and the Blackwater Heritage State Trail, and this will require a sufficient height to provide access along these routes. It has been prescribed that a minimum 12 feet clearance be provided between the Blackwater Heritage State Trail and the low member of the proposed bridge.

- As with the Clear Creek Bridge, the 50 year ARI flood stage with an additional two feet debris clearance will be used as the major factor setting the required minimum low member elevation.

With the above factors considered, and the sources of data that are available, design lengths and minimum low chord elevations were able to be estimated for the preliminary design.

In the vicinity of Pat Brown Road, the low member elevation will need to provide sufficient clearance for vehicular movement. Additionally, a 12 feet clearance is required over the Blackwater Heritage State Trail, and hence, a minimum low member elevation of 27.70 feet NAVD is required.

The bridge length will be required to span the entire regulated floodway of the Blackwater River, and additionally, span to ensure that clearance of Pat Brown Road and the Blackwater Heritage State Trail occurs. As such, the bridge length can be set to a design length of 5,560 feet. The proposed bridge location and length can be seen on **Figure 11** in **Appendix A**.

As detailed analysis of the Blackwater River has occurred by FEMA, and the peak flows have been determined as being comparable to those derived in this study, the 50 year stage at the site of the proposed bridge was read from Figure 01P of the FEMA Flood Study (FEMA, 2006). As the proposed bridge crossing is located approximately 2.3 miles (12,100 feet) upstream of the Confluence of Clear Creek, and at the approximate location of Transect 'L', the stage was adopted as 18 feet. As the proposed bridge will span the regulated floodway and an allowance of a maximum 1 foot stage increase could occur with blockage of the floodplain, the post bridge scenario was taken as a stage of 19 feet NAVD. With the required 2 feet debris clearance, the minimum bridge deck low member elevation over the river should be set as 21 feet NAVD.

As the construction of the bridge embankment will cause some obstruction to flow area on the Southern end of the bridge, some Flood Fringe designated area and wetland will be lost. Remediation techniques that have been outlined for use includes a mitigation bank credit purchase, or a Senate Bill Mitigation for wetland impacts. Additionally, an area of floodplain constructed to a lower elevation will also be constructed to account for the lost volume of floodplain by the roadway/bridge embankment. This may be offset by pre-post modeling during the design phase.

4 Scour Analysis

4.1 General

Bridge scour refers to the lowering/movement of the streambed in the vicinity of bridge crossings. It is the biggest cause of bridge failure in the United States *(Florida Department of Transportation, May 2005)*. Therefore, it is important that the potential for scour is analyzed during the design of any bridge so that the bridge foundations can be designed accordingly and such failures can be prevented.

Bridge scour can generally be divided into the following categories:

1. Lateral channel movement;

2. Long term aggradation / degradation;

3. Contraction scour; and,

4. Local pier and abutment scour.

Due to the limited scope of this preliminary design analysis, only item 1 will be evaluated in detail and items 2-4 will be reviewed for scour potential.

4.2 Soil Description

A NRCS SSURGO soils map for the project area is provided in **Figure 5** in **Appendix A**. Key properties for each soil unit in the vicinity of the proposed SR 87 Connector Bridges are also summarized in **Table 9**. **Figure 5** and **Table 9** indicate that the soils immediately adjoining both Clear Creek and Blackwater River generally comprise sand.

The soil properties provided in **Table 9** include the erosion factor, K, which provides an indication of the susceptibility of the soil to sheet and rill erosion from water flow. The soils adjoining the proposed bridge sites are mainly map units 1, 3, 21, and 34. As can be seen from **Table 9** below, these soils generally comprise sand, and have a high Erosion Factor (K), which indicates high erosion potential.

Table 9: Existing Soils Properties based on NRCS Soil Survey

Map Unit Symbol	Soil Name	Hydrologic Soil Group	Erosion Factor K
1	Albany loamy sand, 0 to 5 percent slopes	290.6	11.2%
3	Bibb-Kinston association	763.2	29.5%
5	Bonifay loamy sand, 0 to 5 percent slopes	186.5	7.2%
8	Dothan fine sandy loam, 0 to 2 percent slopes	10.9	0.4%
9	Dothan fine sandy loam, 2 to 5 percent slopes	9.0	0.3%
14	Fuquay loamy sand, 0 to 5 percent slopes	19.4	0.7%
18	Johns fine sandy loam	64.8	2.5%
19	Kalmia loamy fine sand, 2 to 5 percent slopes	85.4	3.3%
21	Lakeland sand, 0 to 5 percent slopes	227.5	8.8%
22	Lakeland sand, 5 to 12 percent slopes	10.1	0.4%
27	Lynchburg fine sandy loam	153.5	5.9%
34	Pactolus loamy sand, 0 to 5 percent slopes	383.2	14.8%
37	Rains fine sandy loam	53.2	2.1%
40	Rutlege loamy sand	148.8	5.8%
44	Troup loamy sand, 0 to 5 percent slopes	64.5	2.5%
46	Troup loamy sand, 8 to 12 percent slopes	22.0	0.8%
47	Troup-Orangeburg-Cowarts complex, 5 to 12	2.3	0.1%

Detailed geotechnical information was also obtained for the project. This included soil borings at two locations along the proposed Blackwater River Bridge alignment, and adjacent to the Blackwater River, and a further boring adjacent to the SR 87 alignment over Clear Creek The geotechnical information was collected by Environmental and Geotechnical Specialists, INC in 2011 and 2012, and a summary of the borings is presented below. The bore positions can be seen on **Figure 7** in **Appendix A**, and the core boring results are provided in **Appendix F**.

<u>Soil Boring B-1</u> (Blackwater River floodplain adjacent to proposed SR 87 alignment)

- 0.0 - 32.5 feet – Loose to medium Dense Medium to Fine Sand (**SP-SM**)
- 32.5 - 65.0 feet – Loose to Medium Dense Silty Fine to Clayey Sand (**SM** to **SC**)
- 65.0 - 82.5 feet - Medium Dense to Sense Medium to Fine Sand (**SP-SM**)
- 82.5 - 100.0 feet - Loose to Medium Dense SIlty Fine Sand (**SM**)

Soil Boring B-2 (adjacent to Blackwater River and proposed SR 87 alignment)

- 0.0 - 25.0 feet – Loose Sand and Fibrous Organics (**SP**-**SM** & **MUCK**)
- 25.0 - 55.0 feet - Loose to Medium Dense Medium to Fine Sand (**SP**-**SM**)
- 55.0 - 65.0 feet - Dense to Very Dense Medium to Fine Sand (**SP**-**SM**)
- 65.0 - 100.0 feet - Loose to Medium Dense Silty Fine Sand (**SM**)

Soil Boring CC-1 (adjacent to Clear Creek and proposed SR 87 alignment)

- 0.0 - 25.0 feet – Loose to Medium Dense Medium to Silty Fine Sand (**SM**)
- 25.0 - 33.0 feet – Medium Dense to Dense Silty Medium Sand with Gravel (**SM**)
- 33.0 - 40.0 feet – Dense Fine Sand (**SP**-**SM**)
- 40.0 - 75.0 feet – Medium Dense Fine to Silty Fine Sand (**SP-SM** to **SM**)
- 75.0 - 100.0 feet – Very Dense Fine to Silty Fine Sand (**SP-SM** to **SM**)
- 100.0 - 110.0 feet – Medium Dense Silty Fine Sand (**SM**)

The results of examination of the two soil borings confirm that the soil around the Blackwater River Bridge alignment is primarily sand, and a high level of erodibility can be expected on exposed ground. However, as the banks of the river are densely vegetated, little erosion is expected to occur in the present state. However, if the vegetation density was to be altered, by means of clearing or a natural process, then significant erosion during flood events could be expected. Consideration of this should be made during the subsequent design phases and appropriate precautions and rehabilitation implemented.

The soil boring at the location of the proposed Clear Creek Bridge, as well as the close similarities in soil properties from the NRCS soil survey indicate that soil properties are similar to those found at the proposed Blackwater River Bridge, and identical precautions and rehabilitation should be implemented at the Clear Creek Bridge site.

4.3 General Scour/Aggradation and Degradation

General scour refers to bed elevation changes associated with the long-term lateral movement of the river channel. Aggradation and degradation refers to the vertical raising and lowering, respectively, of an entire river reach over extended time-frames.

The potential for general scour and aggradation and degradation in the vicinity of the two proposed SR 87 connector bridges was assessed based on procedures outlined in the Federal Highway Administration Hydraulic Engineering Circular No. 20 *(HEC-20)*, titled "Stream Stability at Highway Structures" *(March 2001).*

A ‘desktop’ geomorphic assessment was conducted for both the proposed bridge crossings of Clear Creek and Blackwater River using procedures outlined in the Federal Highway Administration Hydraulic Engineering Circular No. 20 (HEC-20), titled “Stream Stability at Highway Structures” (March 2001). The assessment provides a summary of the geomorphic characteristics of the basin. The assessment was completed using available online data sources such as digital elevation models, land use mapping, soils mapping and aerial photographs. The outcomes of this assessment are summarized in **Plate 6 and 7** for Clear Creek and Blackwater River respectively (the section numbers refer to the HEC-20 document).

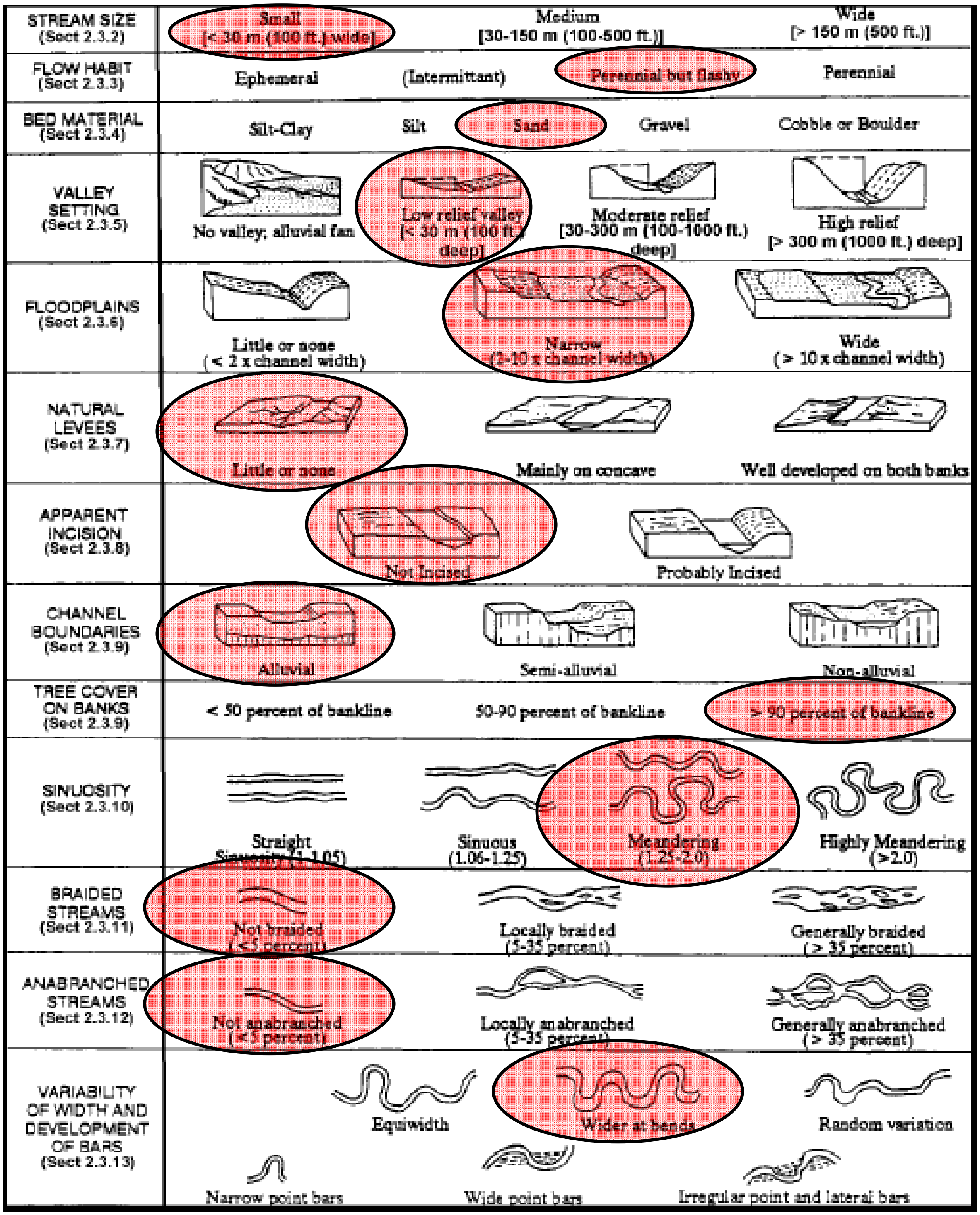


Plate 6: Assessment of Clear Creek geomorphic characteristics at the proposed bridge site

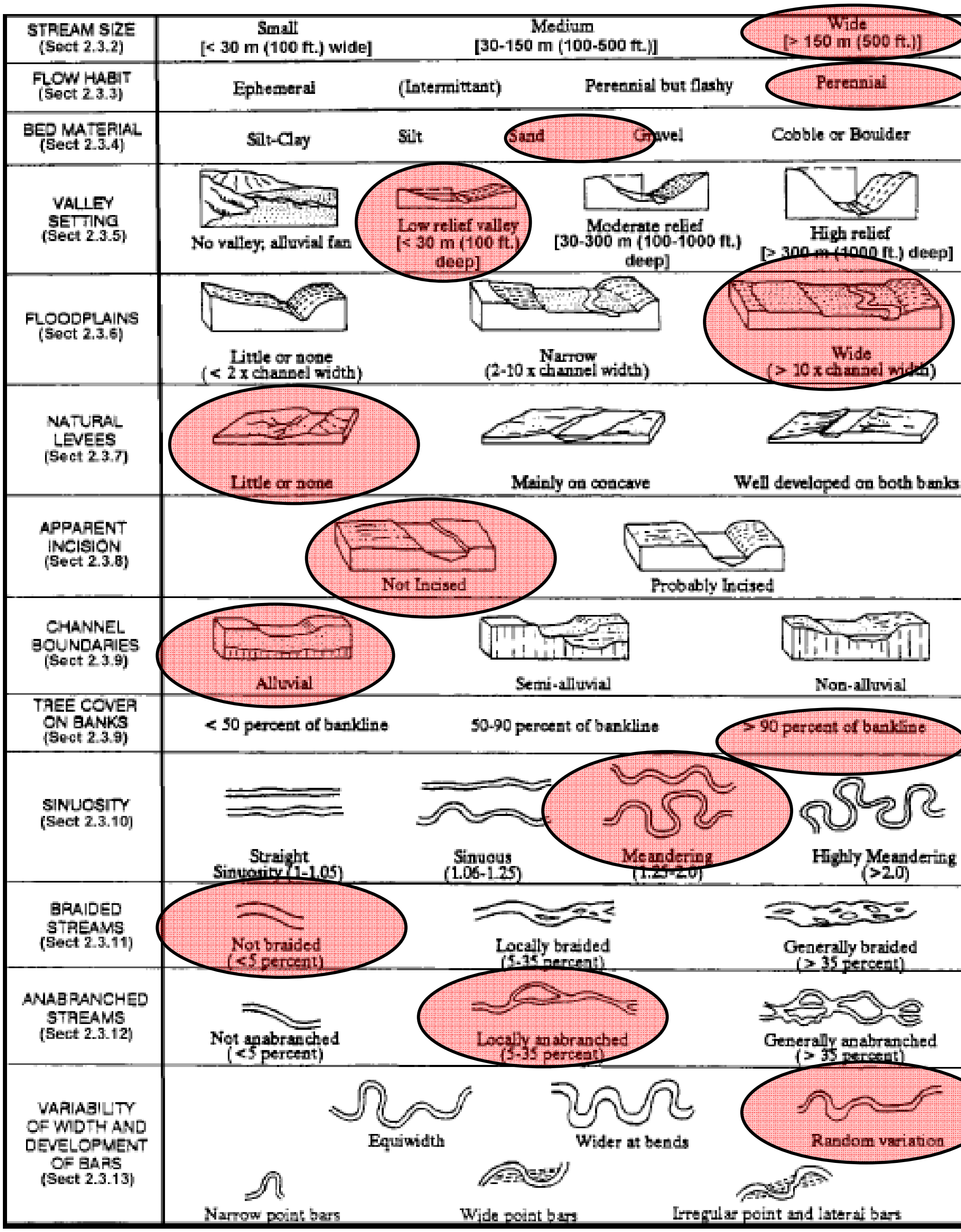


Plate 7: Assessment of Blackwater River geomorphic characteristics at the proposed bridge site

General scour as well as aggradation and degradation are natural geomorphic processes associated with the natural evolution and development of a river and its associated floodplain over extended time periods. Both scour mechanisms can occur without the presence of a bridge. That is, this scour type is not restricted to the vicinity of bridge crossings.

An assessment of general scour has been undertaken for Clear Creek and Blackwater River based on a review of historic aerial photographs dating back to 1966. The outcomes of this assessment are presented in **Figure 8 and 9** in **Appendix A**. As shown in **Figure 8 and 9**, no significant migration of either watercourse has occurred over the past 56 years. This indicates the channels are relatively stable and there is unlikely to be any significant lateral channel movement over the design life of the bridges, if current vegetation conditions are maintained.

Additionally, a review of geomorphic characteristics of both the Clear Creek and Blackwater River basin was completed (refer Section 2.3). The "bed material", "channel boundaries", "valley setting", "natural levee" and "apparent incision" indicate that there is potential for channel scour to occur. However, the "tree cover" and lack of any "anabranched" or "braided" streams tend to illustrate that there is only limited potential for lateral movement of the two channels.

In order to evaluate the potential for aggradation and degradation at the site of the proposed bridges, investigation into previous studies in the locality was undertaken to attempt to determine if aggradation/degradation is likely to occur. The Bridge Hydraulic Report for SR 87 over Clear Creek by Volkert INC (Volkert, 1996) studies a bridge replacement for the crossing of SR 87 in a position upstream of the current proposed location. This report states that through inspection reports and field reviews, there was no indication that long term changes in bed elevations have occurred or are expected to occur in the future.

FDOT has prepared design surge hydrographs based on surge estimates prepared by the Florida Department of Environmental Protection, the US Army Corps of Engineers Waterways Experiment Station and the National Oceanic and Atmospheric Administration. "In 2003, Dr. Sheppard was commissioned by FDOT to investigate the various design storm surge guidance and the methodologies supporting the guidance. His report and a spreadsheet documenting his recommendations for locations around the state have been adopted as policy for design hurricane boundary conditions for Florida DOT." (www.dot.state.fl.us/rddesign/dr/DHSH.shtm). This project is located at reference number 103. The storm surge peak elevations are 9.40/9.08 feet and 10.80/10.48 feet (NGVD 1929/NAVD 1988), respectively, for the 50 and 100 year floods.

As a result, a storm surge can be expected to impact on the proposed location of the SR 87 connector bridge over Blackwater River, and further consideration during design should reflect this. Additionally, a wind induced receding tide in Blackwater Bay may produce the deepest scour potential at the proposed bridge locations. This is associated with a lower tailwater level in Blackwater Bay potentially producing a steeper energy grade line along Blackwater River and consequently Clear Creek.

As a result of the investigations outlined above, it is considered that both the Clear Creek and Blackwater River channels are fairly stable in terms of General and

Aggradation/Degradation Scour, and hence these mechanisms are not considered critical to design of the bridges. Items 3 and 4 will be evaluated with more detailed borings, D50 analysis and the output of a 2D model. The low tailwater, high flow condition scenario should also be investigated as a steeper energy grade line will exist, and may lead to higher velocities, and consequently, higher scour potential.

5 Summary and Conclusion

This report has presented the outcomes of investigations that were completed to determine design flows at the two proposed bridge sites and determine a preliminary minimum low chord elevation and bridge span lengths for the SR 87 connector bridge crossings of Blackwater River and Clear Creek.

A detailed hydrologic analysis has been undertaken and presented, providing design flows for floods between the 5 and 500 year ARI event. These flows are considered the best estimate and as such were utilized in the hydraulic modeling to determine the required low chord elevation and width of the bridges over the Blackwater River and Clear Creek.

Based on the outcomes of the hydraulic investigations and for planning purposes, it is recommended that the proposed bridge spanning Clear Creek comprise a span length of 180 feet, and have a minimum low member elevation of 18.95 feet NAVD. This will ensure that the bridge is elevated sufficiently high to allow debris clearance in the design 50 year ARI flood, and ensure stages do not increase more than 1 foot upstream of the proposed bridge. Realignment of the creek will need to occur to ensure the span length can be minimized and to help ensure water is distributed through the bridge opening more efficiently.

It is recommended that the proposed bridge to span Blackwater River be 5,560 feet long. The bridge should have a minimum low member elevation of 21 feet NAVD over the river and floodplain, and a minimum low member elevation of 27.70 feet NAVD over the Blackwater Heritage State Trail. Similarly to the proposed Clear Creek Bridge, these low chord elevations and span lengths make allowance for 2 feet debris clearance, as well as ensuring upstream stage increases are less than 1 foot. In addition, the length of the bridge will also allow for the spanning of Pat Brown Road, and the Blackwater Heritage State Trail.

As this is a preliminary study, these parameters may vary after a more detailed hydraulic investigation is undertaken. Due to the meandering nature of the Blackwater River in the vicinity of the proposed Blackwater River Bridge site, a 2-dimensional model should be utilized in order to gain a greater understanding of flood behavior, and more specifically, provide accurate stage and velocity parameters in which will define the majority of design requirements. Greater investigation into appropriate tailwater and the variation in the tailwater during extreme events should be undertaken and considered in design and scour calculations.

The detailed investigation of the Clear Creek Bridge should utilize tailwater estimates produced from the Blackwater River model. Additionally, consideration of the hydraulic impacts of all structures downstream of the proposed bridge site to the confluence of Blackwater River should be included. It may be prudent to include the Clear Creek design within the Blackwater River 2-dimension model. An environmentally sensitive method of dealing with the parallel channel alignment with the proposed Clear Creek Bridge should also be identified and may require spanning of the entire channel, or a re-alignment through the bridge opening.

The design stage of both proposed bridges should utilize surveyed cross-section data and more detailed Mannings 'n' values derived from analysis of vegetation and bank conditions at each proposed bridge site.

6 References

1. Environmental and Geotechnical Specialists, INC (November 2011). *Phase I Geotechnical Investigation*: Bridge Investigation SR 87 Connector PD&E Study Santa Rosa County Florida

2. Environmental and Geotechnical Specialists, INC (December 2012). Report Of Geotechnical Bridge Investigation. SR 87 Over Clear Creek Connector Bridge PD&E Study, Santa Rosa County Florida

3. Federal Emergency Management Agency (December 19, 2006). *Flood Insurance Rate Maps, Santa Rosa County, Florida and incorporated Areas*. Community-Panel Number 340 of 657.

4. Florida Department of Transportation (2012). *Drainage Manual*.

5. Florida Department of Transportation (May, 2005). *Bridge Scour Manual*.

6. Federal Emergency Management Agency (1996). *Flood Insurance Study, Santa Rosa County, Florida And Incorporated Areas.*

7. Federal Highway Administration (1984). *Guide for Selecting Manning's Roughness Coefficient For Natural Channels and Flood Plains.*

8. Metric Engineering (2012). *Draft Bridge Hydraulics Report for Blackwater River*

9. Metric Engineering (2012). *Draft Bridge Hydraulics Report for Clear Creek*

10. Volkert Inc (August 2010). *Bridge Hydraulics Report FDOT SR 87 Over Clear Creek, Project Development and Environmental Phase Santa Rosa County, Florida*

APPENDIX A

FIGURES

SR 87 Connector Proposed Bridge Crossings over Clear Creek and Blackwater River

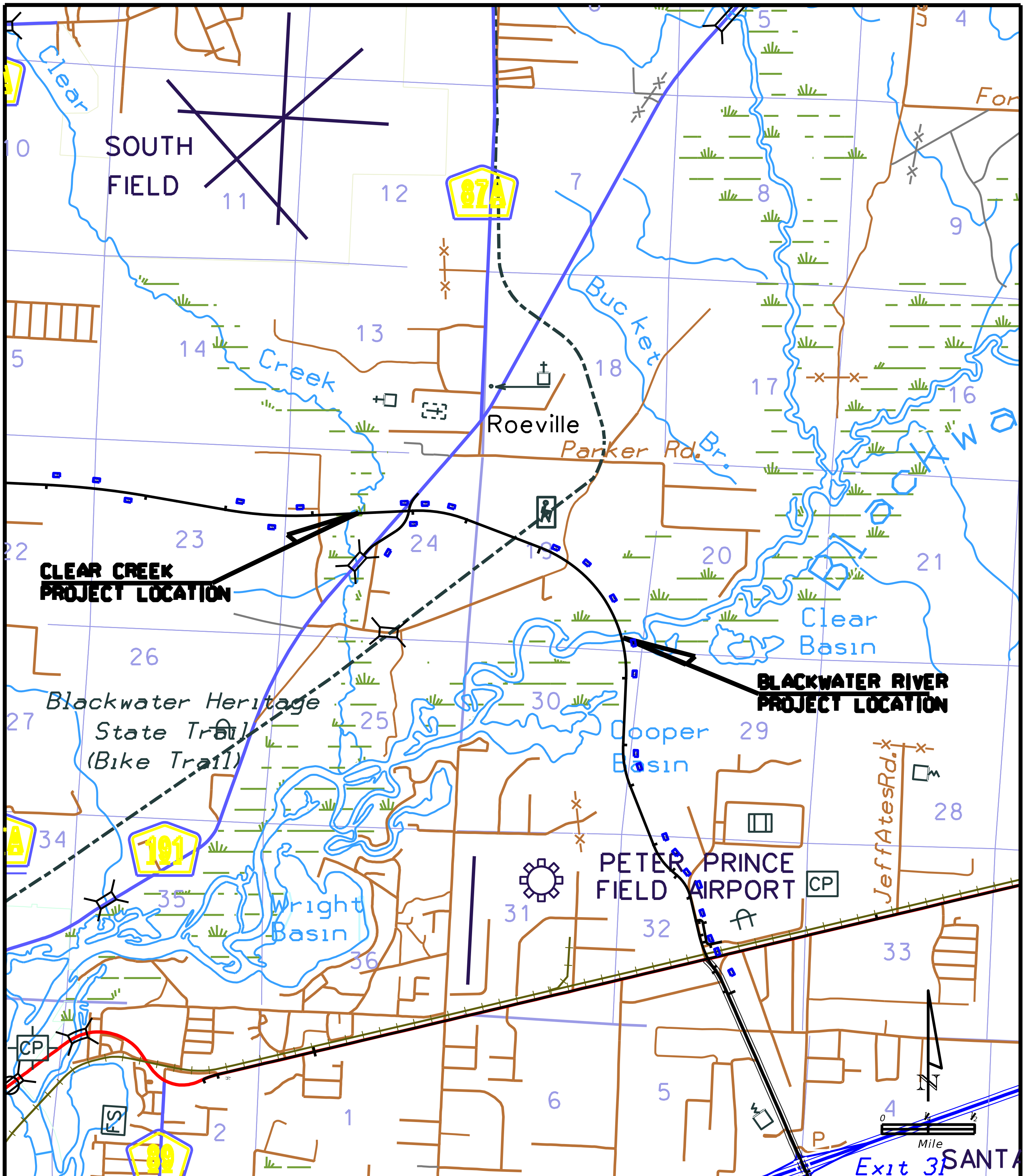
Technical Memorandum

Financial Project ID

416748-3-32-01

Santa Rosa County, Florida

165 Lincoln Avenue
Winter Park, FL 32889
Phone: 407.629.2185
Fax: 407.629.2183
www.balmoralgroup.us



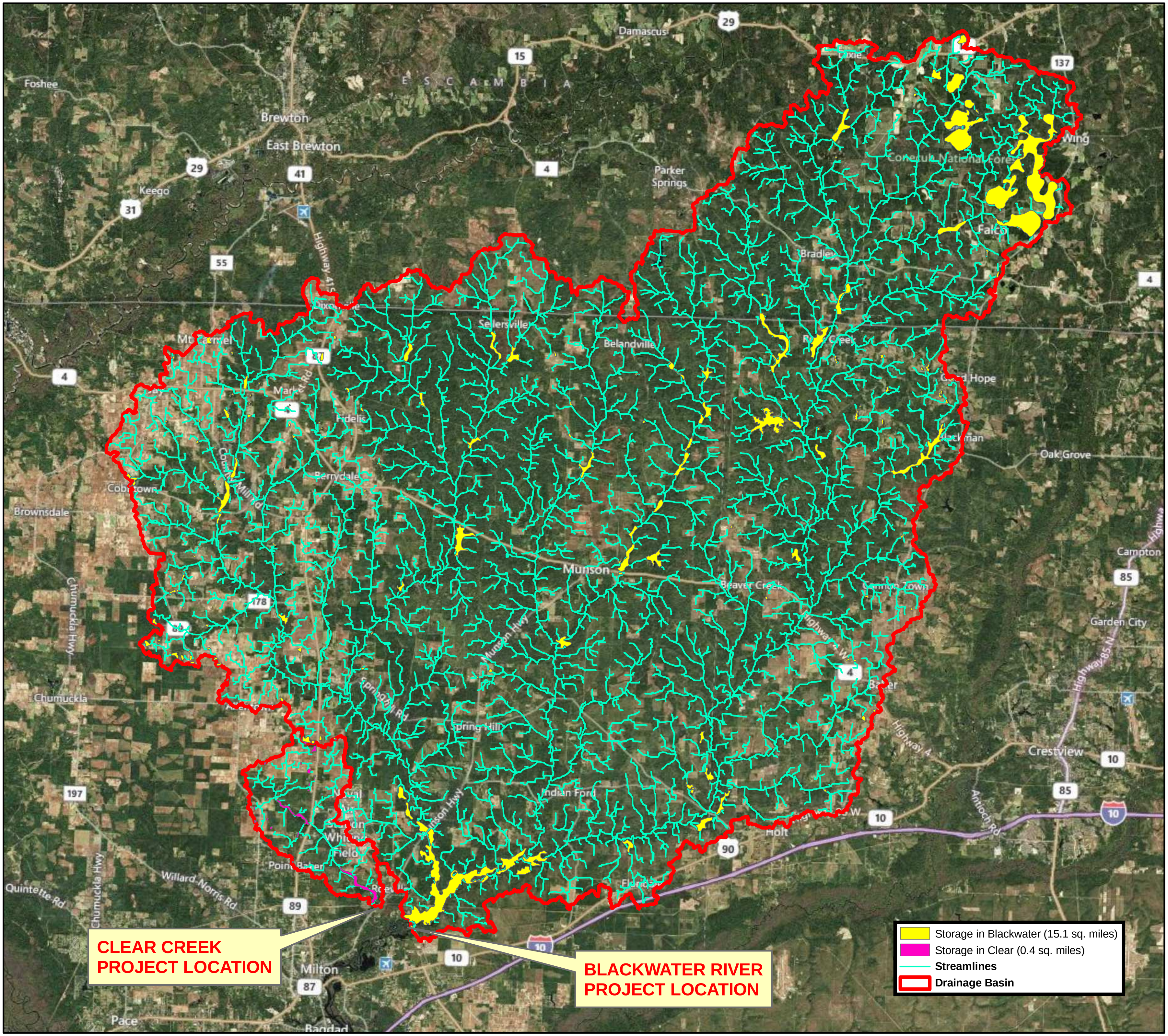
The Balmoral Group

165 Lincoln Avenue
Winter Park, FL 32789
Phone: (407) 629-2185
Fax: (407) 629-2183
Certificate of Authorization No. 26123

E.O.R.: Gregory S. Seidel, P.E. No. 47571

Figure #1
Location Map
FDOT District 3 - SR 87 Connector
FPID 416748-3-32-01
Santa Rosa County, Florida

$FILE$ $TIME$ $DATE$ $USER$



The Balmoral Group
165 Lincoln Avenue
Winter Park, FL 32789

Project Site

N

0 10,000 20,000 Feet

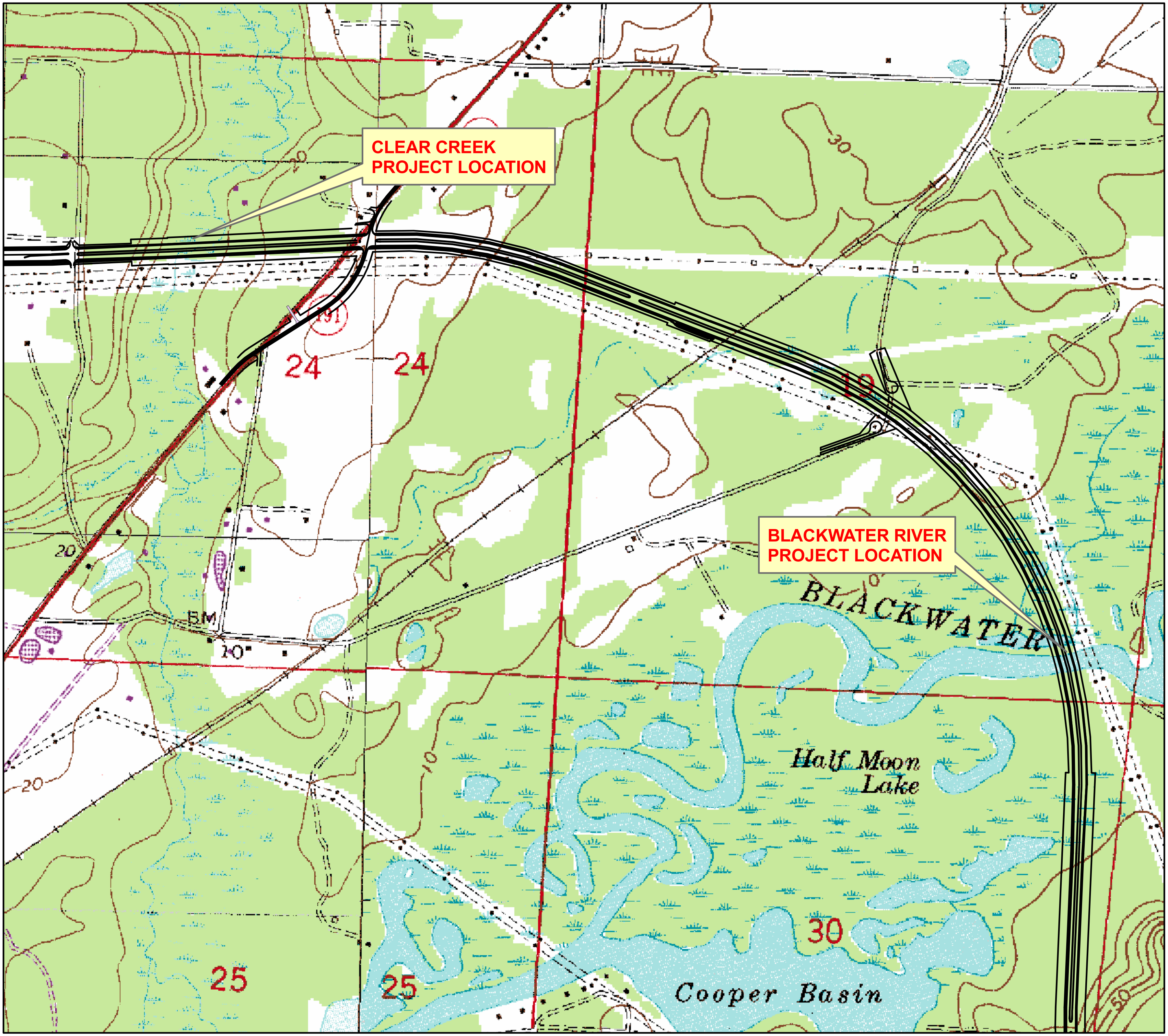
FIGURE #2

DRAINAGE BASIN MAP

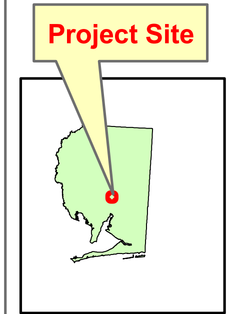
FPID: 416748-3-32-01

SR 87 CONNECTOR

Santa Rosa County, Florida



165 Lincoln Avenue
Winter Park, FL 32789



N

0 375 750 Feet

FIGURE #3

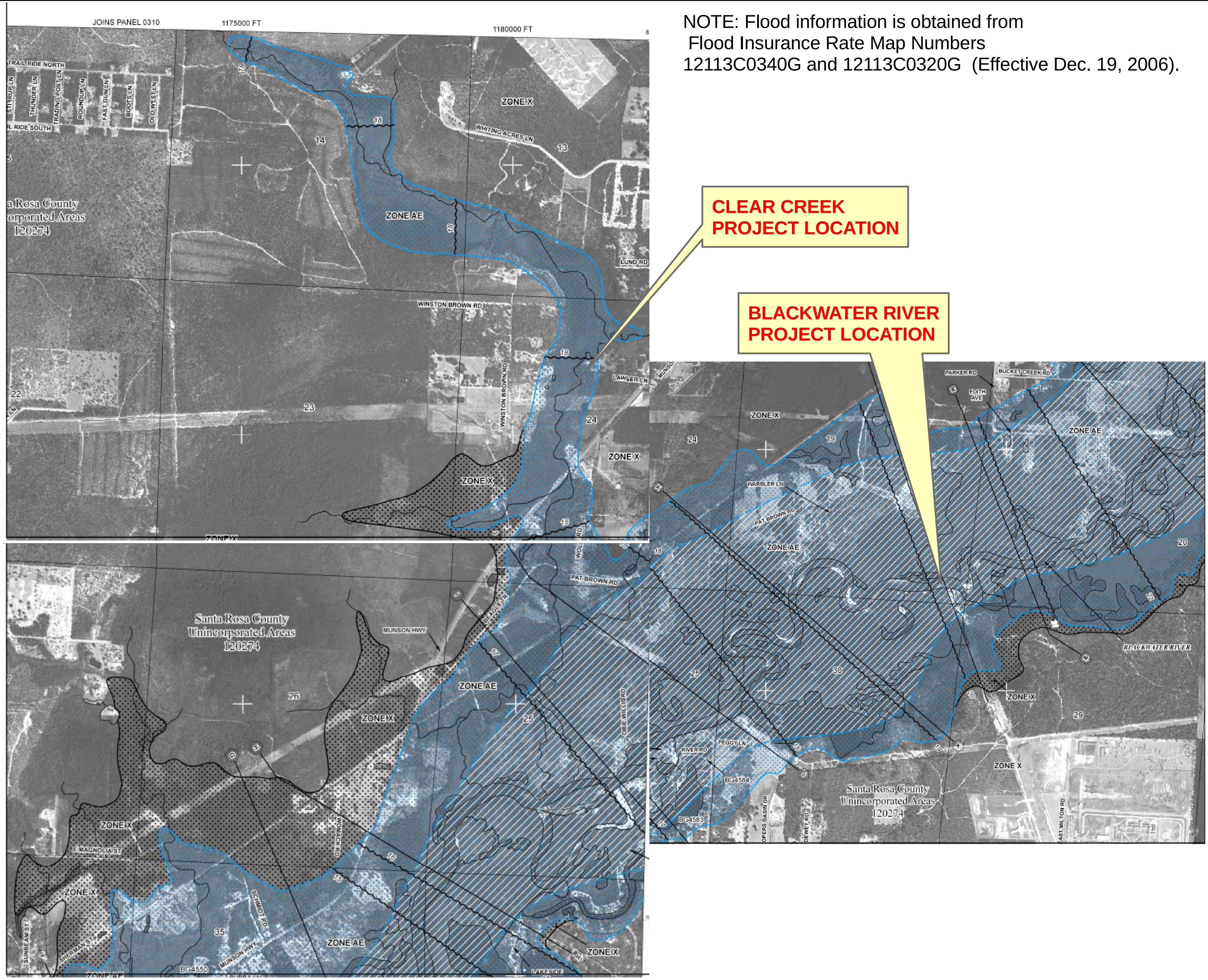
QUAD MAP

FPID: 416748-3-32-01

SR 87 CONNECTOR

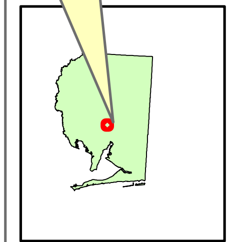
Santa Rosa County, Florida

NOTE: Flood information is obtained from Flood Insurance Rate Map Numbers 12113C0340G and 12113C0320G (Effective Dec. 19, 2006).



165 Lincoln Avenue
Winter Park, FL 32789

Project Site



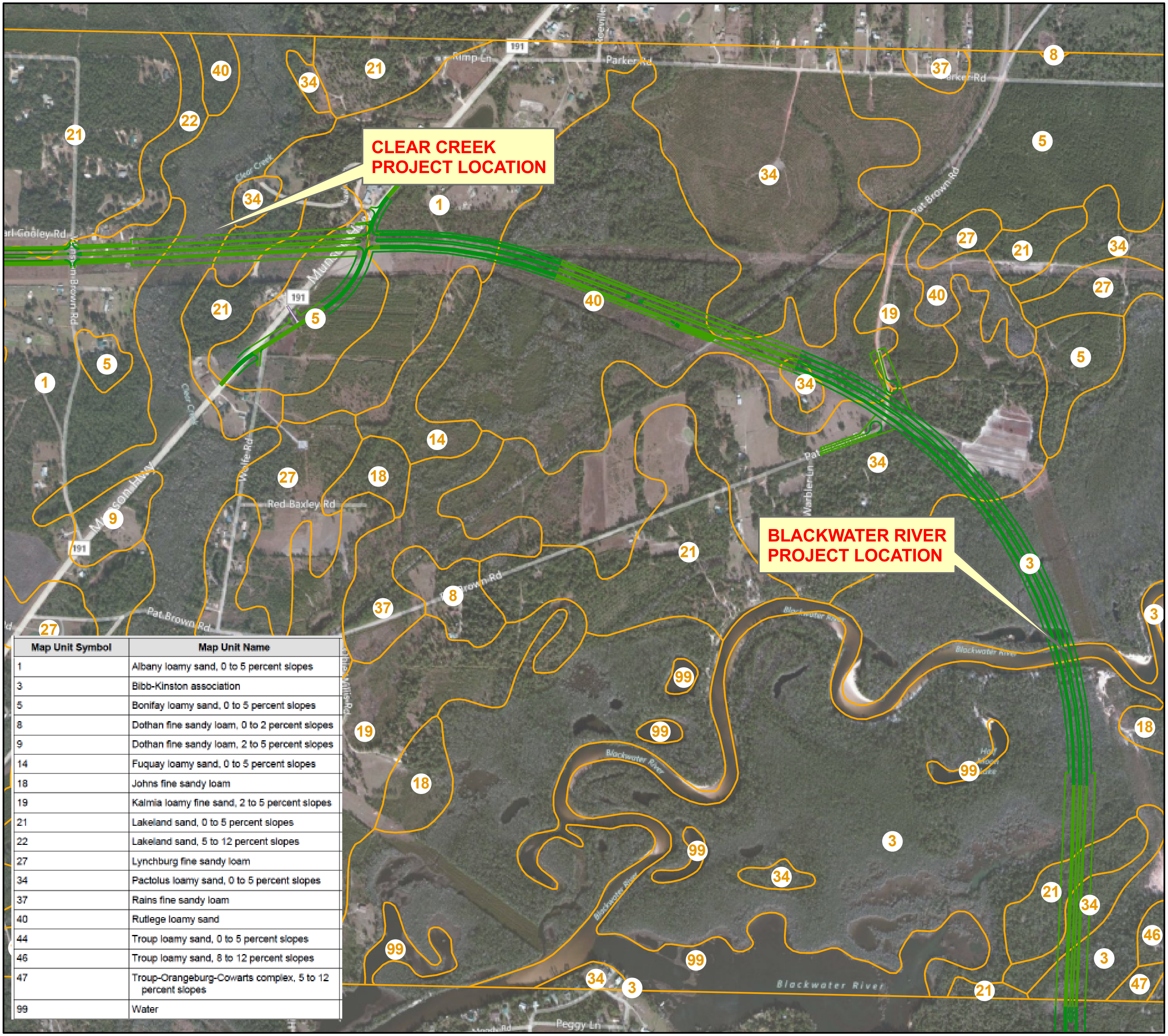
N

FIGURE #4
FLOOD MAP

FPID: 416748-3-32-01

SR 87 CONNECTOR

Santa Rosa County, Florida



Map Unit Symbol	Map Unit Name
1	Albany loamy sand, 0 to 5 percent slopes
3	Bibb-Kinston association
5	Bonifay loamy sand, 0 to 5 percent slopes
8	Dothan fine sandy loam, 0 to 2 percent slopes
9	Dothan fine sandy loam, 2 to 5 percent slopes
14	Fuquay loamy sand, 0 to 5 percent slopes
18	Johns fine sandy loam
19	Kalmia loamy fine sand, 2 to 5 percent slopes
21	Lakeland sand, 0 to 5 percent slopes
22	Lakeland sand, 5 to 12 percent slopes
27	Lynchburg fine sandy loam
34	Pactolus loamy sand, 0 to 5 percent slopes
37	Rains fine sandy loam
40	Rutlege loamy sand
44	Troup loamy sand, 0 to 5 percent slopes
46	Troup loamy sand, 8 to 12 percent slopes
47	Troup-Orangeburg-Cowarts complex, 5 to 12 percent slopes
99	Water

The Balmoral Group
165 Lincoln Avenue
Winter Park, FL 32789

Project Site

Soil Types

SOIL DATA OBTAINED FROM NRCS WEB SOIL SURVEY.

N

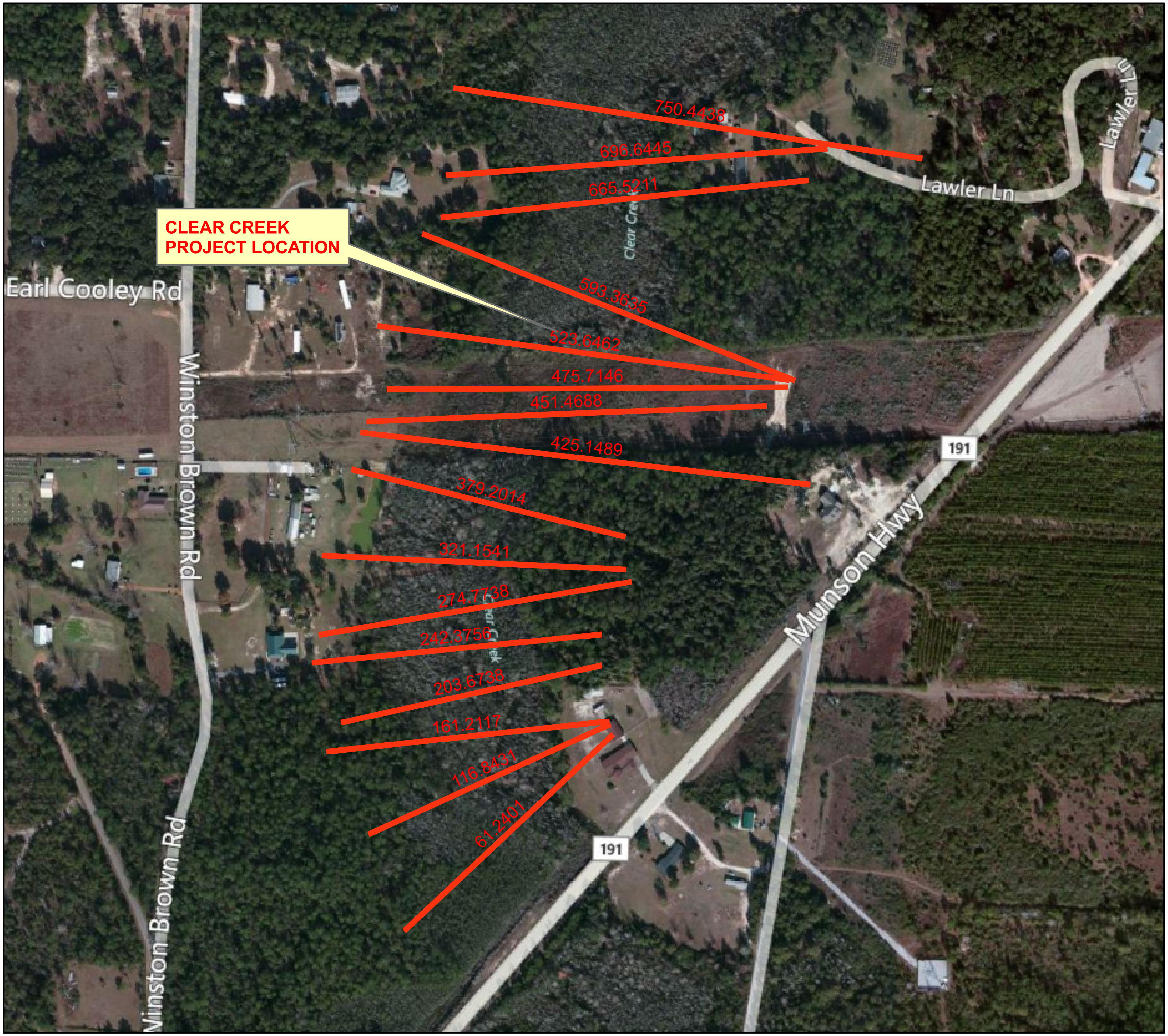
0 375 750 Feet

FIGURE #5
SOIL MAP

FPID: 416748-3-32-01

SR 87 CONNECTOR

Santa Rosa County, Florida



The Balmoral Group
165 Lincoln Avenue
Winter Park, FL 32789

Project Site

HEC-RAS CROSS SECTIONS

N

0 150 300 Feet

FIGURE #6

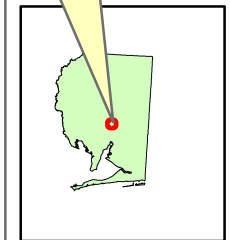
CROSS SECTIONS CLEAR CREEK

FPID: 416748-3-32-01

SR 87 CONNECTOR

Santa Rosa County, Florida

The Balmoral Group
165 Lincoln Avenue
Winter Park, FL 32789



N

0 500 1,000 Feet

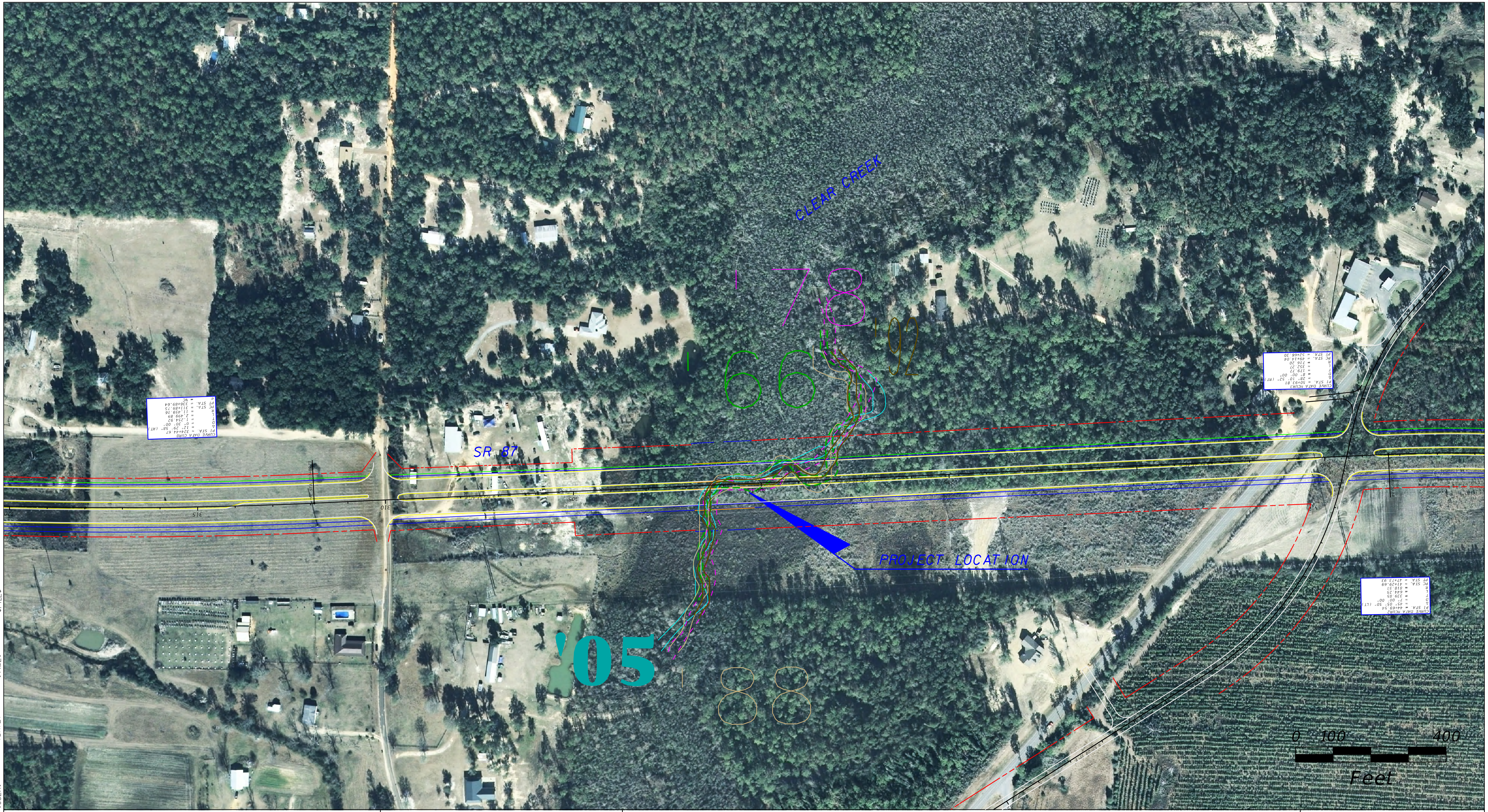
FIGURE #7

AERIAL

FPID: 416748-3-32-01

SR 87 CONNECTOR

Santa Rosa County, Florida

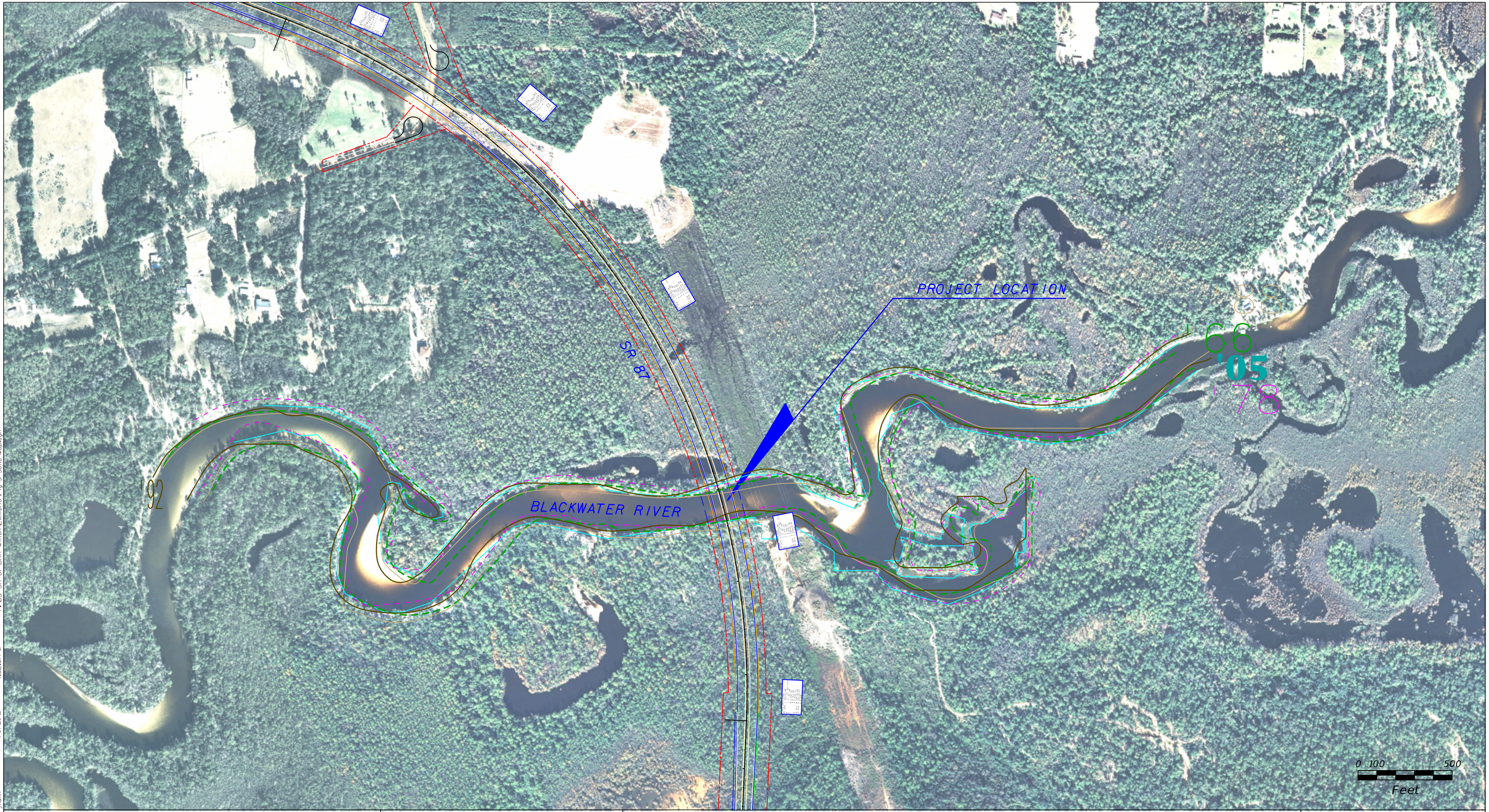


165 Lincoln Avenue
Winter Park, FL 32789
Phone: (407) 629-2185
Fax: (407) 629-2183
Certificate of Authorization No. 26123

E.O.R.: Gregory S. Seidel, P.E. No. 47571

N

Figure 8
Channel Geomorphology of Clear Creek
FDOT District 3
SR 87 Connector
Financial Project ID 416748-3-32-01
Santa Rosa County, Florida

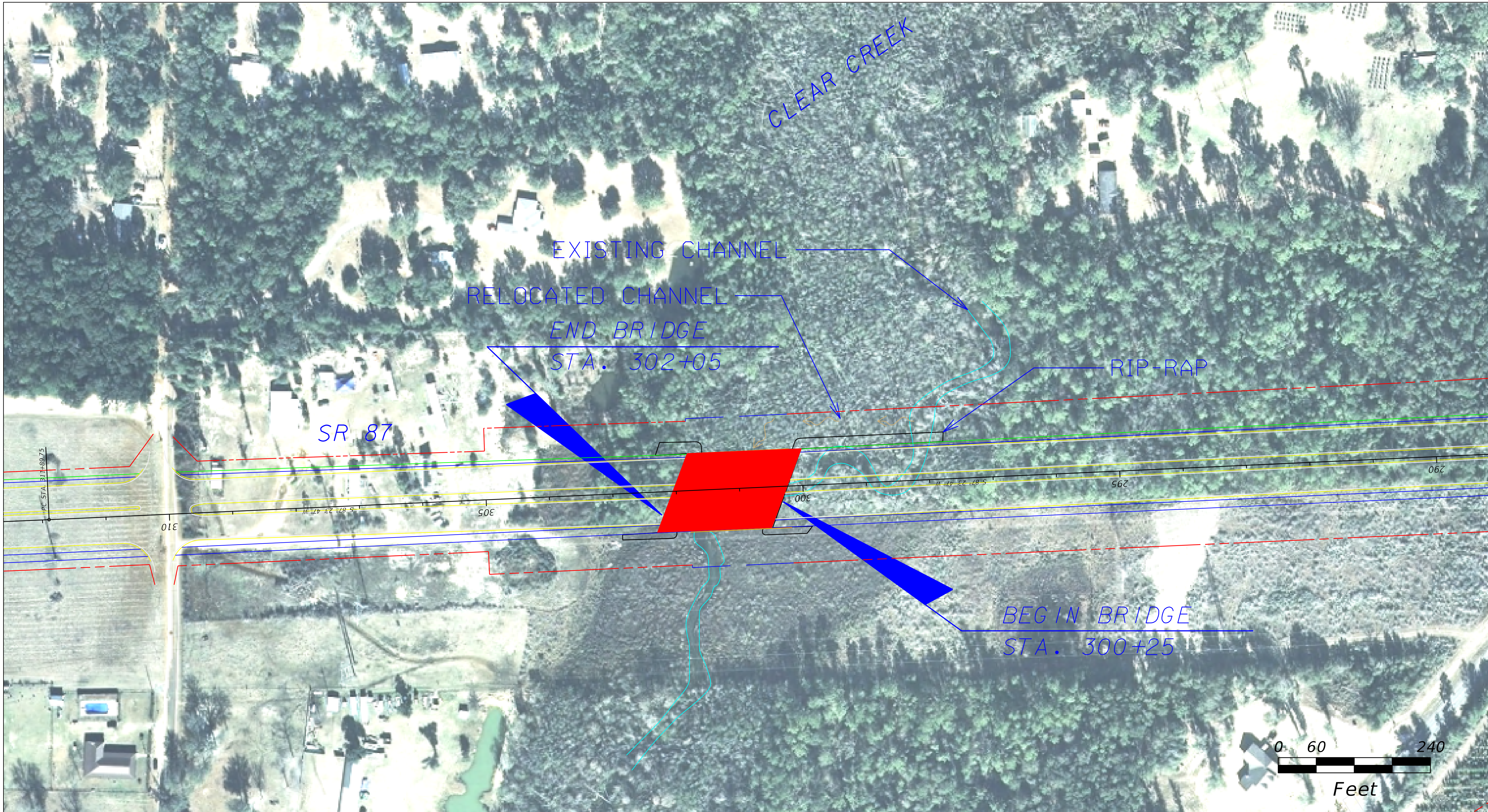


165 Lincoln Avenue
Winter Park, FL 32789
Phone: (407) 629-2185
Fax: (407) 629-2183
Certificate of Authorization No. 26123

E.O.R.: Gregory S. Seidel, P.E. No. 47571

N

Figure 9
Channel Geomorphology of Blackwater River
FDOT District 3
SR 87 Connector
Financial Project ID 416748-3-32-01
Santa Rosa County, Florida

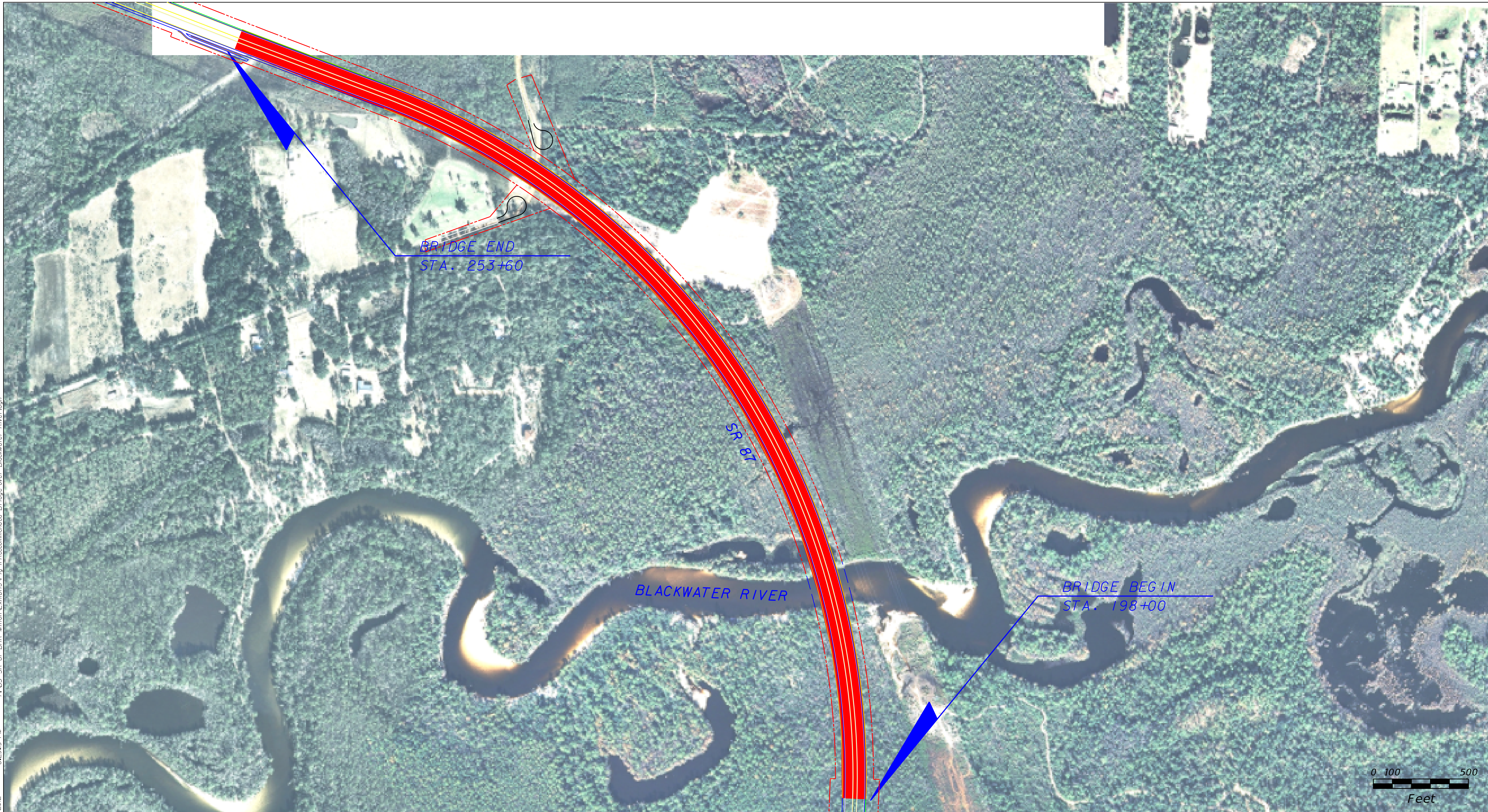


The Balmoral Group
165 Lincoln Avenue
Winter Park, FL 32789
Phone: (407) 629-2185
Fax: (407) 629-2183
Certificate of Authorization No. 26123

E.O.R.: Gregory S. Seidel, P.E. No. 47571

N

Figure 10
Reccommended Bridge over Clear Creek
FDOT District 3
SR 87 Connector
Financial Project ID 416748-3-32-01
Santa Rosa County, Florida



The Balmoral Group
165 Lincoln Avenue
Winter Park, FL 32789
Phone: (407) 629-2185
Fax: (407) 629-2183
Certificate of Authorization No. 26123

E.O.R.: Gregory S. Seidel, P.E. No. 47571

N

Figure 11
Reccommended Bridge over Blackwater River
FDOT District 3
SR 87 Connector
Financial Project ID 416748-3-32-01
Santa Rosa County, Florida

APPENDIX B

HYDROLOGIC FACTOR AND PEAK FLOWS

SR 87 Connector Proposed Bridge Crossings over Clear Creek and Blackwater River

Technical Memorandum

Financial Project ID

416748-3-32-01

Santa Rosa County, Florida

165 Lincoln Avenue
Winter Park, FL 32889
Phone: 407.629.2185
Fax: 407.629.2183
www.balmoralgroup.us

Appendix B - Hydrologic Factor Generation and Peak Flows

Inputs

	Area (sq.miles)	Calibrated Mean Catchment Slope (ft/mile)	Calibrated % Lakes
Big Coldwater Creek Gage	238	13.1	0.14
Blackwater River Gage	206	15.0	0.54
Proposed Bridge Crossing Clear Creek	22.88	29.1	0.77
Proposed Bridge Crossing Blackwater River	704	9.1	0.32
Louisville and Nashville Railroad crossing	749	8.9	0.37

Gages

Big Coldwater Creek Gage

ARI	Flood Frequency Analysis Q(cfs)	USGS Regression Q (cfs)	Calibrated Q (cfs)
5	11800	9060	12100
10	17570	12900	17900
25	27420	19200	27400
50	36960	25200	36700
100	48720	31800	47300
200	63120	39700	59900
500	87110	51900	80300

Blackwater River Gage

ARI	Flood Frequency Analysis Q(cfs)	USGS Regression Q (cfs)	Calibrated Q (cfs)
5	8970	7930	10100
10	13330	11200	14700
25	20640	16600	22200
50	27610	21600	29500
100	36070	27100	37700
200	46280	33600	47300
500	62980	43700	62600

Bridge Sites

Proposed Bridge Site on Clear Creek

ARI	USGS Regression Q (cfs)	Calibrated Q (cfs)
5	1630	2040
10	2300	2940
25	3320	4330
50	4240	5640
100	5220	7020
200	6310	8570
500	7940	11000

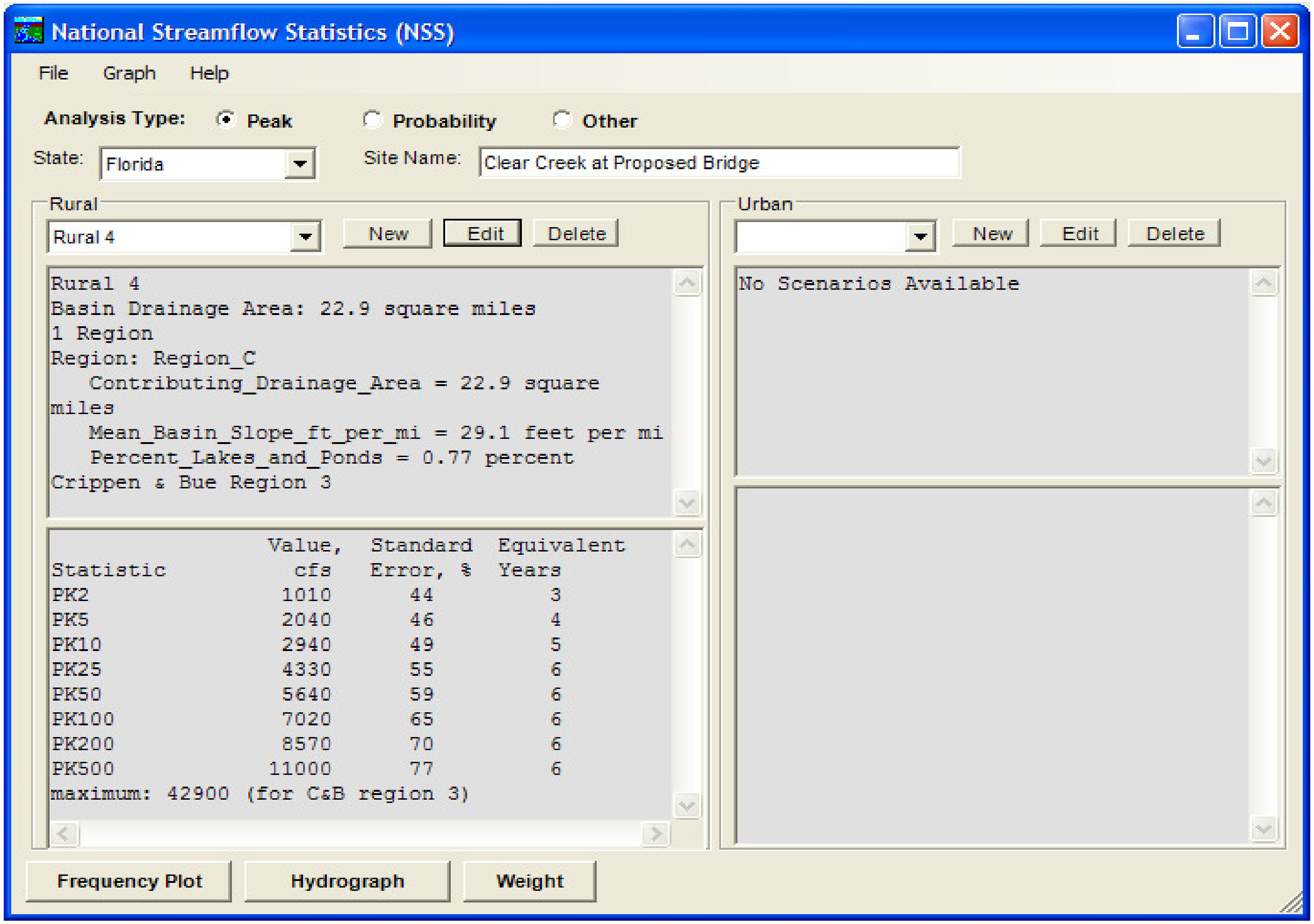
Proposed Bridge Site on Blackwater River

ARI	USGS Regression Q (cfs)	Calibrated Q (cfs)
5	18300	24100
10	25900	35100
25	38500	53600
50	50400	71700
100	64000	92700
200	80400	118000
500	106000	159000

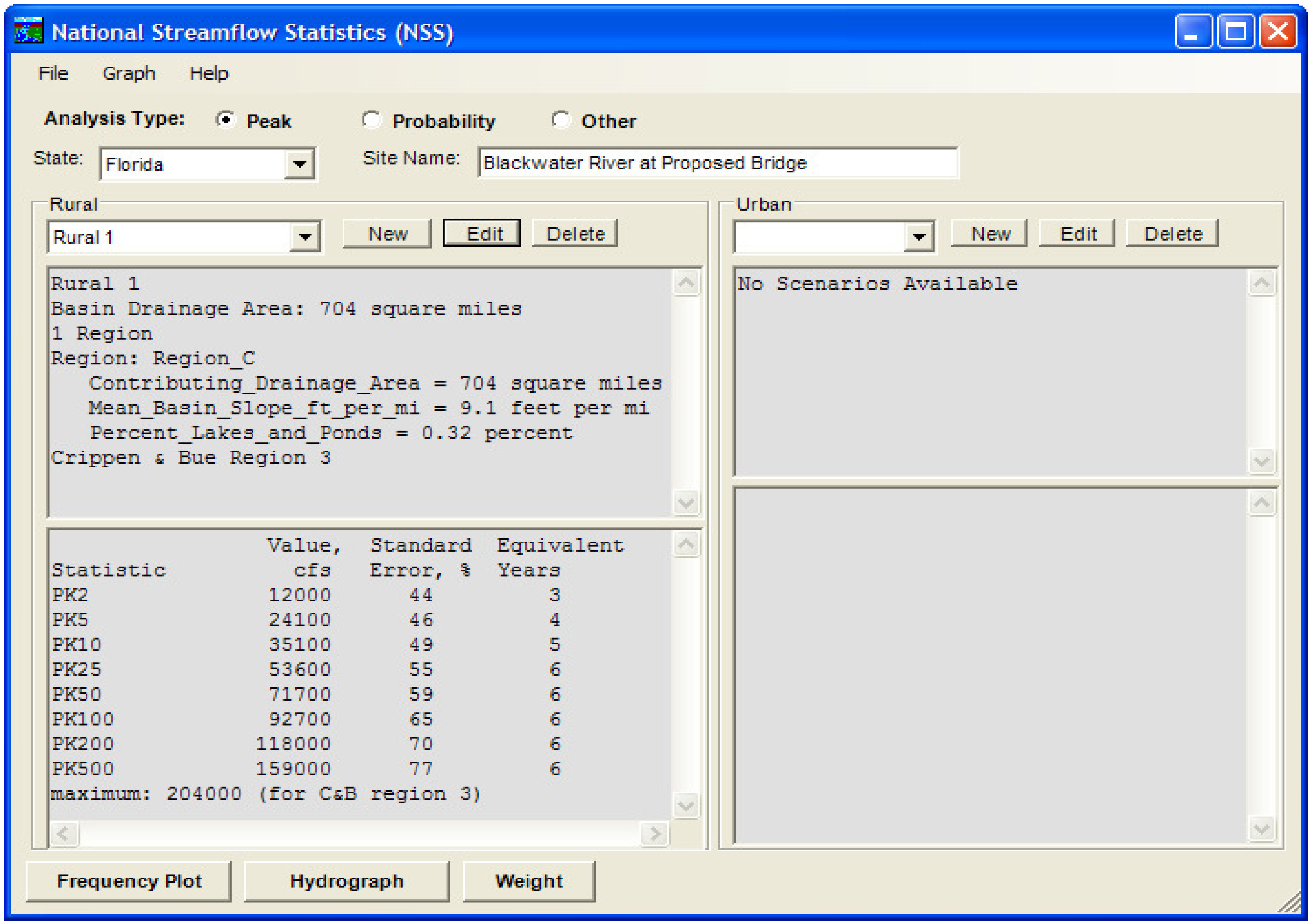
Verification

ARI	USGS Regression Q (cfs)	1996 FEMA FIS	Calibrated Q (cfs)
5	19000	NA	24700
10	26900	35900	36000
25	39900	NA	54900
50	52200	69900	73400
100	66300	89900	94700
200	83300	NA	121000
500	110000	152900	162000

Clear Creek at Proposed Bridge - NSS Output



Blackwater River at Proposed Bridge - NSS Output



APPENDIX C

HEC-RAS HYDRAULIC MODEL OUTPUTS

SR 87 Connector Proposed Bridge Crossings over Clear Creek and Blackwater River

Technical Memorandum

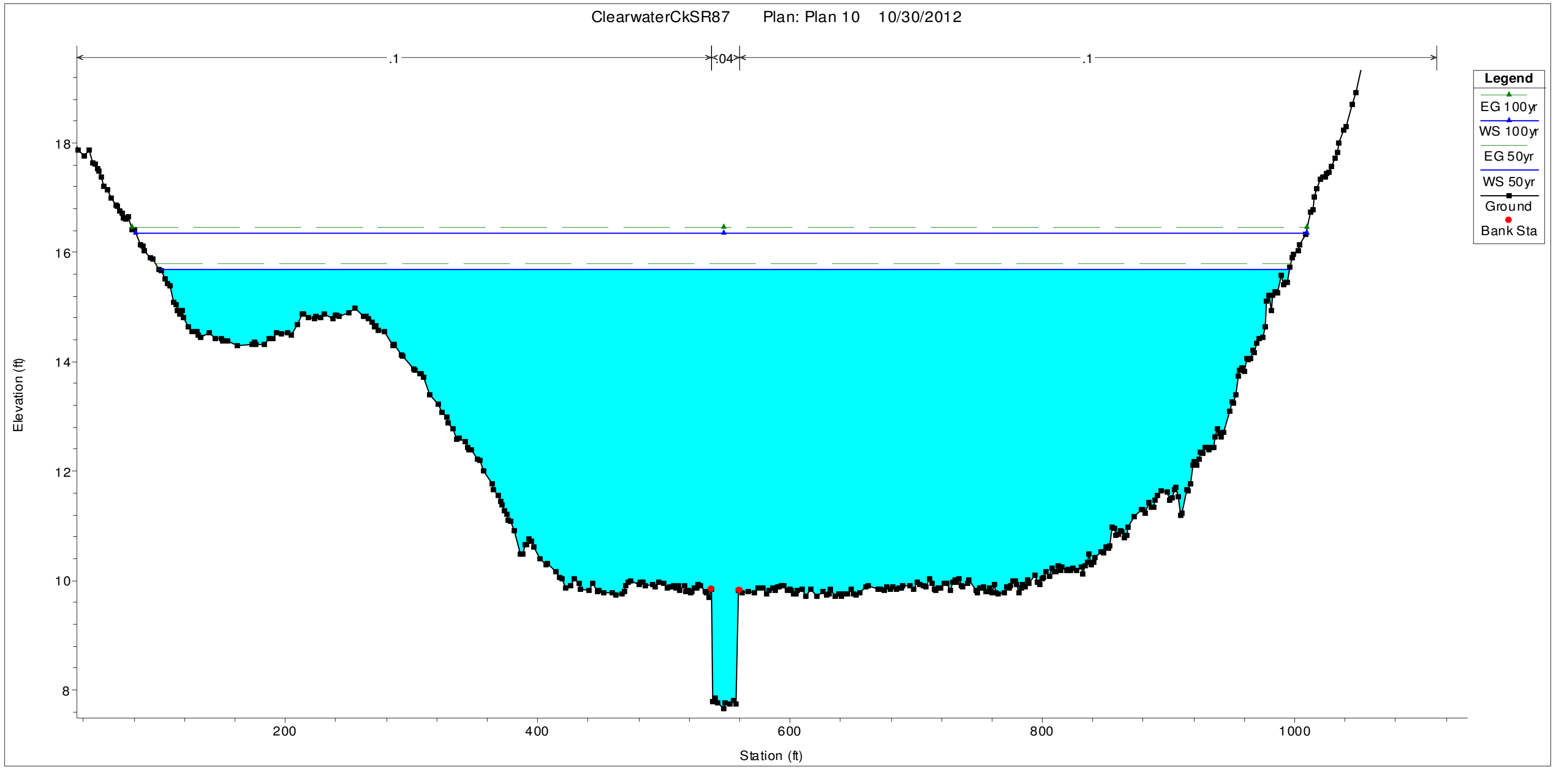
Financial Project ID

416748-3-32-01

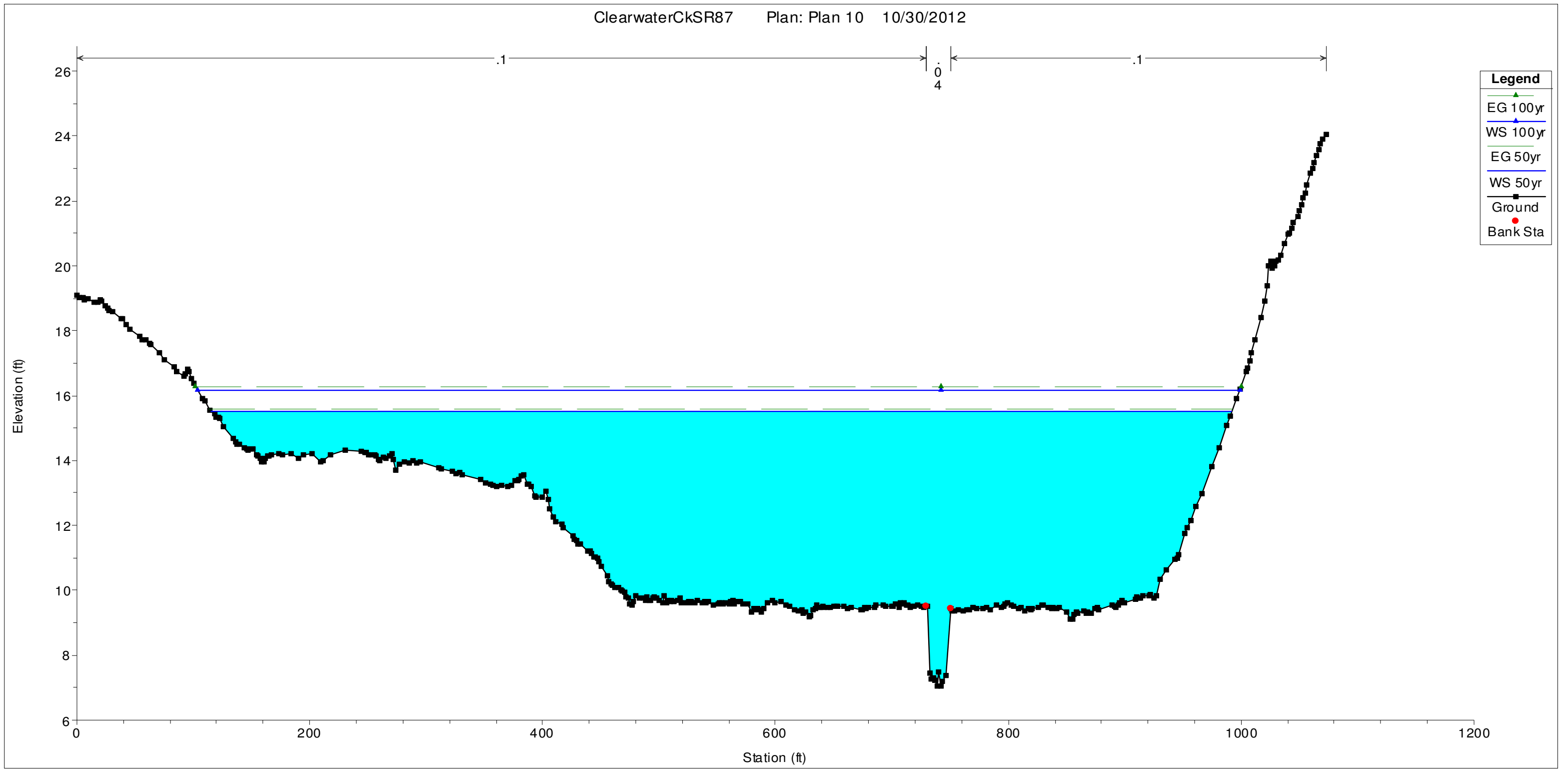
Santa Rosa County, Florida

165 Lincoln Avenue
Winter Park, FL 32889
Phone: 407.629.2185
Fax: 407.629.2183
www.balmoralgroup.us

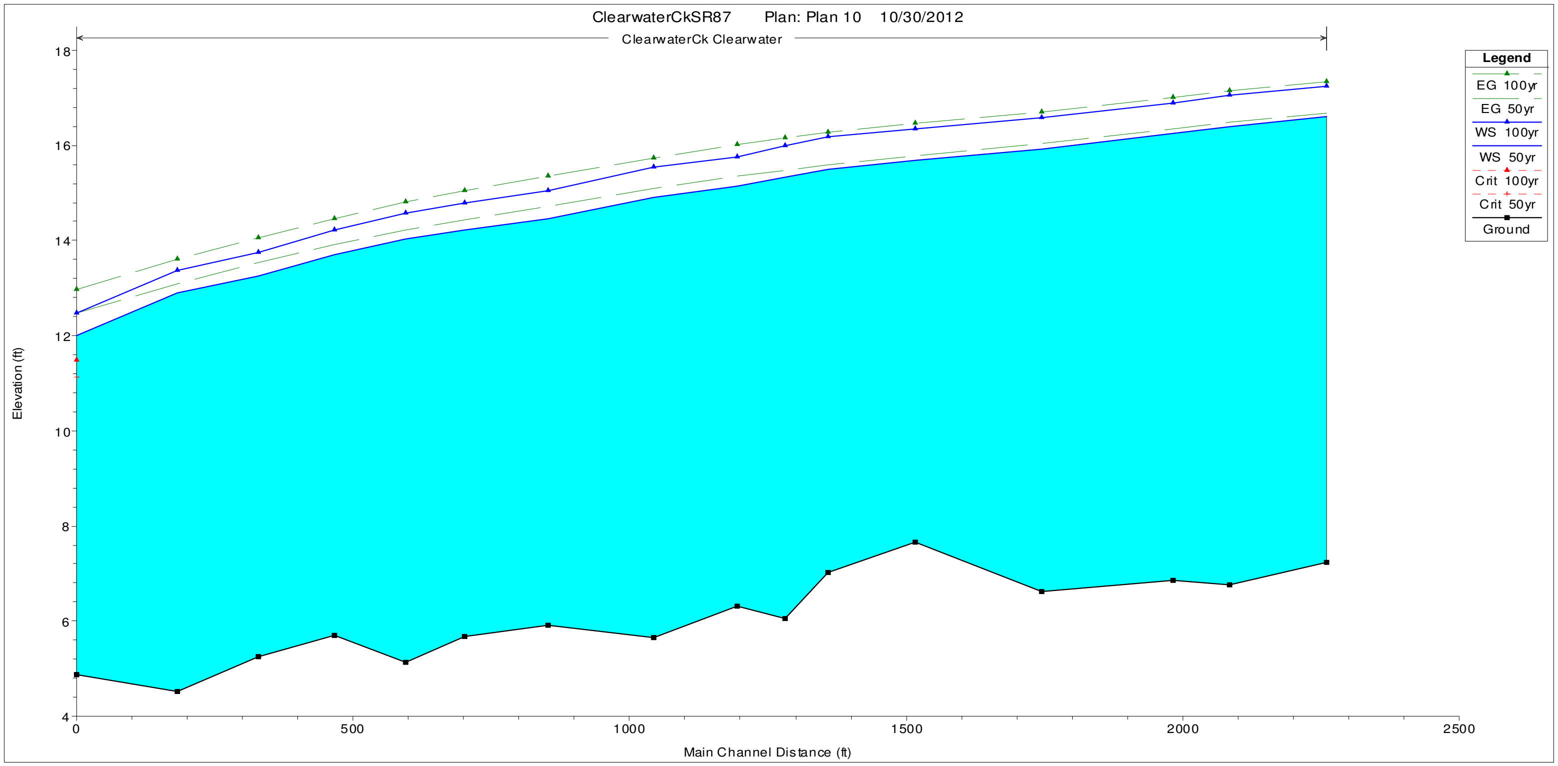
Appendix C - HEC-RAS Hydraulic Model Outputs



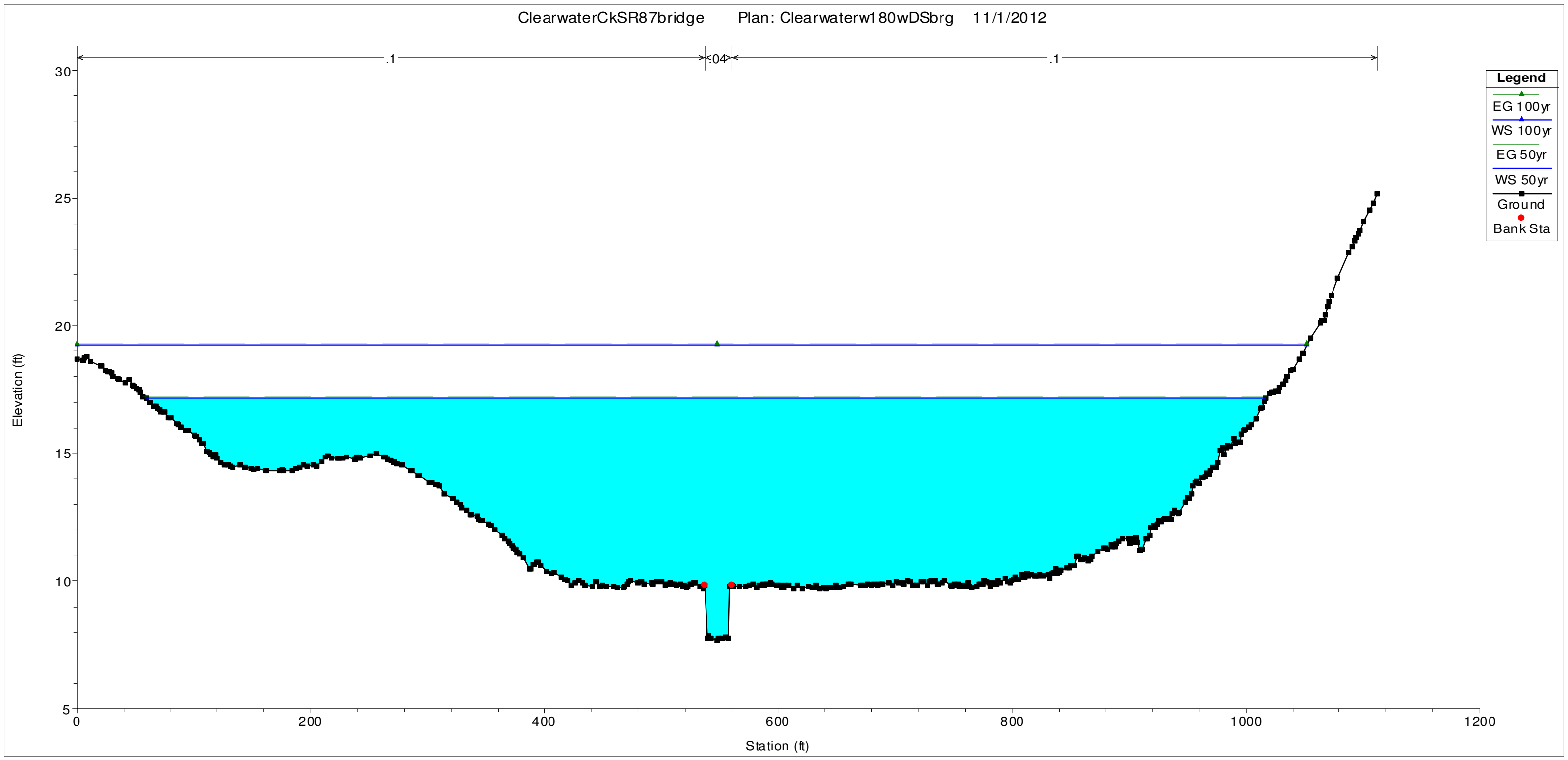
Cross Section 523 - Existing Scenario



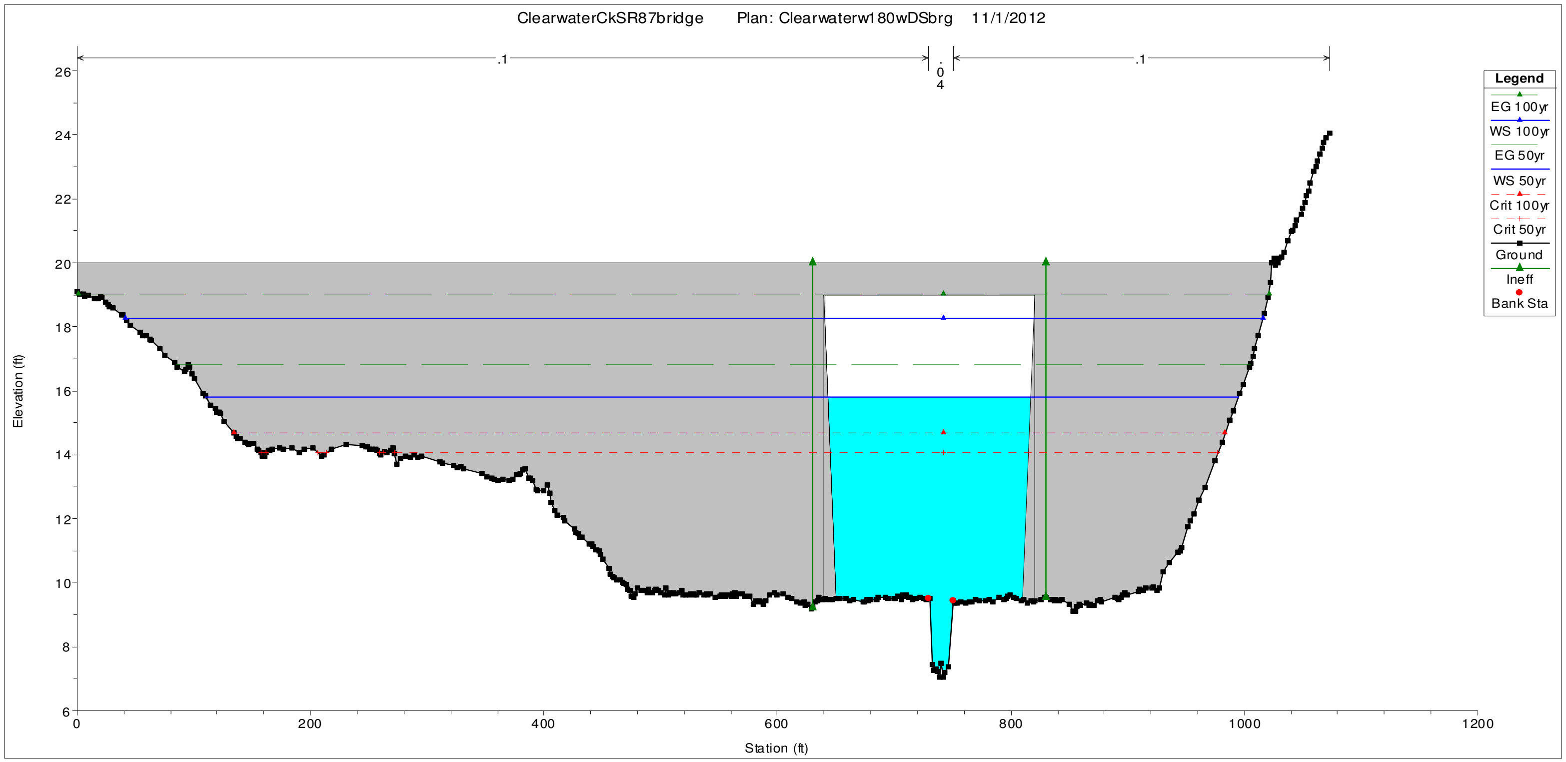
Cross Section 460 - Existing Scenario



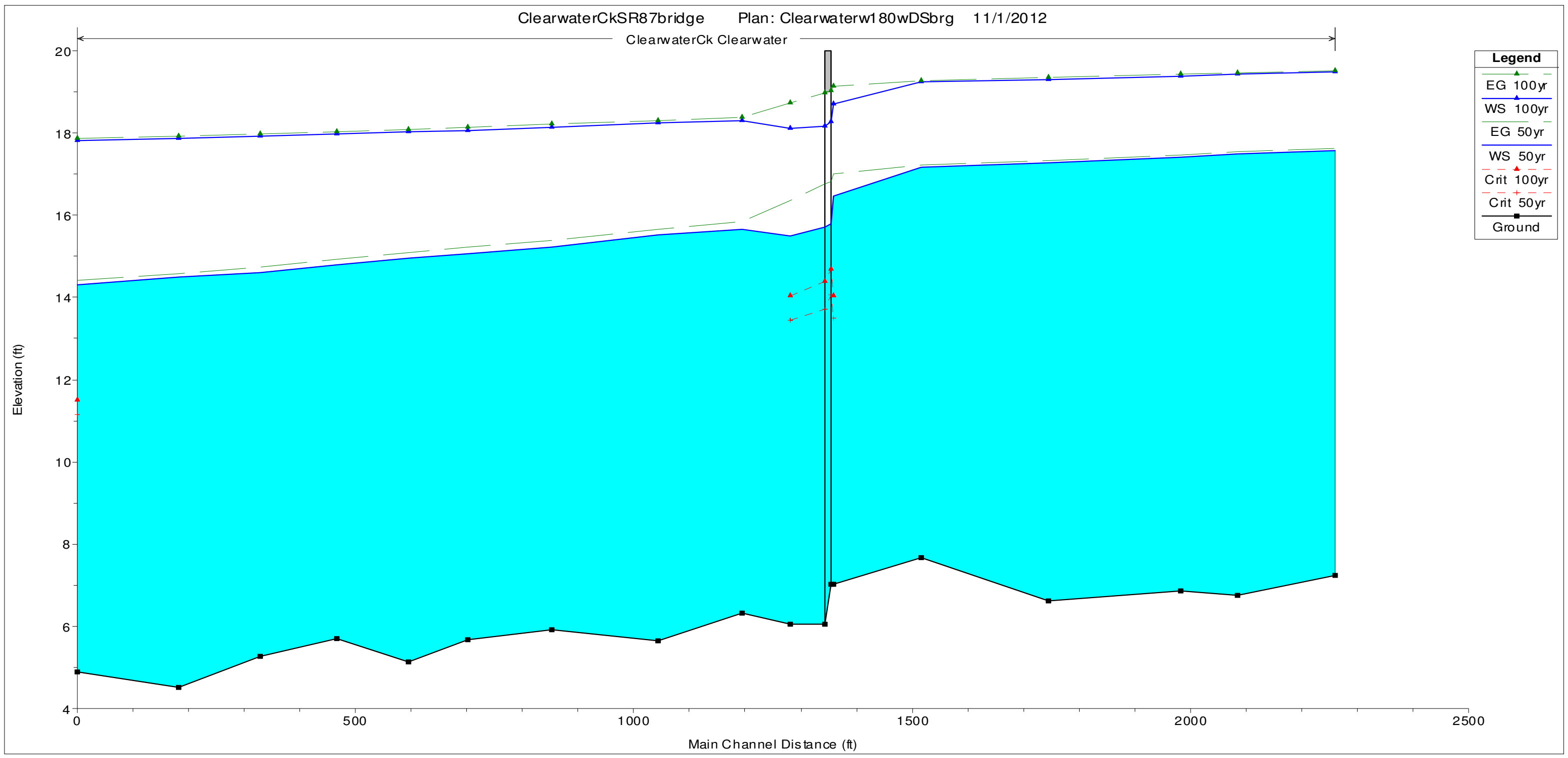
Flood Level Profile - Existing Scenario



Cross Section 523 - Proposed Bridge Scenario



Cross Section 460 - Proposed Bridge Scenario



Flood Level Profile - Proposed Bridge Scenario

Profile Output Table - Standard Table 1

HEC-RAS Plan: Plan 01 River: ClearCk Reach: Clear Ck Reach: Clear Ck

Rivers = 1
Hydraulic Reaches = 1
River Stations = 16
Plans = 1
Profiles = 2

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Ch
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Clear Ck	750.4438	50yr	5640	7.23	17.36		17.41	0.000452	2.95	5110.99	1265.81	0.19
Clear Ck	750.4438	100yr	7020	7.23	19.36		19.39	0.000227	2.44	7631.64	1265.81	0.14
Clear Ck	696.6445	50yr	5640	6.76	17.26		17.32	0.000604	3.51	4469.6	943.53	0.22
Clear Ck	696.6445	100yr	7020	6.76	19.3		19.34	0.000326	2.99	6410.46	962.19	0.16
Clear Ck	665.521	50yr	5640	6.86	17.19		17.25	0.000769	3.98	4362.67	927.85	0.24
Clear Ck	665.521	100yr	7020	6.86	19.26		19.3	0.00038	3.23	6302.89	951.68	0.17
Clear Ck	593.3634	50yr	5640	6.62	17.04		17.1	0.000444	3.34	4856.95	929.39	0.19
Clear Ck	593.3634	100yr	7020	6.62	19.18		19.22	0.000255	2.9	6936.21	1022.71	0.15
Clear Ck	523.6461	50yr	5640	7.66	16.95		16.99	0.00058	3.63	4822.36	952.04	0.21
Clear Ck	523.6461	100yr	7020	7.66	19.13		19.16	0.000307	3.06	7011.92	1050.67	0.16
Clear Ck	475.7146	50yr	5640	7.03	16.29	13.35	16.79	0.003778	9.12	1401.51	898.85	0.55
Clear Ck	475.7146	100yr	7020	7.03	18.63	13.9	19.03	0.002308	8.36	1868.79	991	0.44
Clear Ck	451.4688	50yr	5640	6.05	15.4	13.27	16.19	0.004227	9.55	1185.96	876.59	0.58
Clear Ck	451.4688	100yr	7020	6.05	18.08	13.89	18.64	0.002219	8.31	1678.46	949.3	0.44

Clear Ck	425.1489	50yr	5640	6.32	15.55		15.72	0.001111	4.7	3064.88	785.84	0.3
Clear Ck	425.1489	100yr	7020	6.32	18.26		18.33	0.00041	3.49	5411.11	927.53	0.19
Clear Ck	379.2014	50yr	5640	5.65	15.41		15.53	0.001308	5.32	3055.78	629.49	0.31
Clear Ck	379.2014	100yr	7020	5.65	18.2		18.26	0.000515	4	4964.66	708.98	0.21
Clear Ck	321.154	50yr	5640	5.92	15.14		15.3	0.001194	5.24	3080.43	661.13	0.31
Clear Ck	321.154	100yr	7020	5.92	18.1		18.18	0.000443	3.87	5235.38	778.36	0.2
Clear Ck	274.7738	50yr	5640	5.68	15		15.13	0.001142	4.82	3143.99	656.16	0.3
Clear Ck	274.7738	100yr	7020	5.68	18.05		18.12	0.000412	3.59	5376.33	791.07	0.19
Clear Ck	242.3755	50yr	5640	5.14	14.9		15.01	0.001108	4.62	3183.88	613.49	0.29
Clear Ck	242.3755	100yr	7020	5.14	18.01		18.07	0.000407	3.5	5256.6	704.15	0.19
Clear Ck	203.6737	50yr	5640	5.7	14.74		14.85	0.001352	4.84	3028.13	597.93	0.31
Clear Ck	203.6737	100yr	7020	5.7	17.96		18.02	0.000471	3.64	5116.34	702.89	0.2
Clear Ck	161.2117	50yr	5640	5.26	14.58		14.7	0.001265	4.91	3087.88	627.96	0.31
Clear Ck	161.2117	100yr	7020	5.26	17.91		17.96	0.000409	3.54	5370.45	741.61	0.19
Clear Ck	116.8431	50yr	5640	4.52	14.46		14.55	0.000805	3.77	3483.44	633.58	0.25
Clear Ck	116.8431	100yr	7020	4.52	17.87		17.91	0.000275	2.86	5720.31	688.58	0.16
Clear Ck	61.2401	50yr	5640	4.88	14.3	11.06	14.41	0.000816	3.88	3391.54	677.61	0.
Clear Ck	61.2401	100yr	7020	4.88	17.82	11.39	17.87	0.000248	2.78	5872.48	738.04	0.

APPENDIX D

MANNINGS N COMPUTATIONS FOR CHANNEL AND OVERBANK

SR 87 Connector Proposed Bridge Crossings over Clear Creek and Blackwater River

Technical Memorandum

Financial Project ID

416748-3-32-01

Santa Rosa County, Florida

165 Lincoln Avenue
Winter Park, FL 32889
Phone: 407.629.2185
Fax: 407.629.2183
www.balmoralgroup.us

Appendix D - Mannings N Computations for Channel and Overbank

SR87 Connector over Clear Creek, Santa Rosa County, Florida

Computer using FHWA's "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains"

Natural Channel:

Base Value, nb	Values from Table 1	Sand (Median Size 0.26mm)	=	0.015	Table :
Irregularity, n1	Eroded,Scalloped Banks? Projecting Points? Exposed Roots along banks?	Minor	=	0.005	Table :
Variation, n2	Alternating Large and Small Cross-Sections? Sharp Bends? Constrictions?	Alternating Frequently	=	0.012	Table :
Obstruction, n3	Logs, Stumps, Boulders, debris, pilings, piers?	Negligible	=	0.001	Table :
Vegetation, n4	Amount of vegetation in wetted perimeter	Small	=	0.003	Table :
Degree of Meandering, m	Ratio of total length of meandering channel to a straight length of channel	Appreciable	=	1.15	Table :
Cowan's Equation [n=(nb+n1+n2+n3+n4)*m]			=	0.0414	
		Adopted	**=**	**0.04**	

Overbank:

Base Value, nb	Values from Table 1	Sand (Median Size 0.26mm)	=	0.015	Table :
Irregularity, n1	Irregularity of the Surface of the Flood Plain	Minor	=	0.005	Table :
Variation, n2	For Floodplains, **always Gradual = 0.0**	N/A	=	0	Table :
Obstruction, n3	Logs, Stumps, Boulders, debris, pilings, piers?	Negligible	=	0.001	Table :
Vegetation, n4	Obstruction by vegetation such as tree trunks and other measurable obstacles	Very Large	=	0.08	Table :
Degree of Meandering, m	Correction Factor for sinuosity of Floodplain, **always 1.0**	N/A	=	1	Table :
Cowan's Equation [n=(nb+n1+n2+n3+n4)*m]			=	0.101	
		Adopted	**=**	**0.1**	

Table 2 . Adjustment Values for Factors that Affect the Roughness of a Channel [modified from Aldridge and Garrett, 1973, Table 2]

Channel Conditions	*n* Value Adjustment[1]	Example
Degree of Irregularity (n_1)		
Smooth	0.000	Compares to the smoothest channel attainable in a given bed material.
Minor	0.001-0.005	Compares to carefully degraded channels in good condition but having slightly eroded or scoured side slopes.
Moderate	0.006-0.010	Compares to dredged channels having moderate to considerable bed roughness and moderately sloughed or eroded side slopes. s in rock.
Severe	0.011-0.020	Badly sloughed or scalloped banks of natural streams; badly eroded or sloughed sides of canals or drainage channels; unshaped, jagged, and irregular surfaces of channel

Variation in channel cross section (n_2)

Channel Conditions	*n* Value Adjustment[1]	Example
Gradual	0.000	Size and shape of channel cross sections change gradually.
Alternating occasionally	0.001-0.005	Large and small cross sections alternate occasionally, or the main flow occasionally shifts from side to side owing to changes in cross-sectional shape.
Alternating frequently	0.010-0.015	Large and small cross sections alternate frequently, or the main flow frequently shifts from side to side owing to changes in cross-sectional shape.

Effect of obstruction (n_3)

Channel Conditions	*n* Value Adjustment[1]	Example
Negligible	0.000-0.004	A few scattered obstructions, which include debris deposits, stumps, exposed roots, logs, piers, or isolated boulders, that occupy less than 5 percent of the cross-sectional area.
Minor	0.005-0.015	Obstructions occupy less than 15 percent of the cross-sectional area, and the spacing between obstructions is such that the sphere of influence around one obstruction does not extend to the sphere of influence around another obstruction. Smaller adjustments are used for curved smooth-surfaced objects than are used for sharp-edged angular objects.
Appreciable	0.020-0.030	Obstructions occupy from 15 percent to 50 percent of the cross-sectional area, or the space between obstructions is small enough to cause the effects of several obstructions to be additive, thereby blocking an equivalent part of a cross section.
Severe	0.040-0.050	Obstructions occupy more than 50 percent of the cross-sectional area, or the space between obstructions is small enough to cause turbulence across most of the cross section.

Amount of vegetation (n_4)

Channel Conditions	*n* Value Adjustment[1]	Example

Small	0.002-0.010	Dense growths of flexible turf grass, such as Bermuda, or weeds growing where the average depth of flow is at least two times the height of the vegetation; supple tree seedlings such as willow, cottonwood, arrowhead, or saltcedar growing where the average depth of flow is at least three times the height of the vegetation.
Medium	0.010-0.025	Turf grass growing where the average depth of flow is from one to two times the height of the vegetation; moderately dense stemy grass, weeds, or tree seedlings growing where the average depth of flow is from two to three times the height of the vegetation; brushy, moderately dense vegetation, similar to 1-to-2-year-old willow trees in the dormant season, growing along the banks, and no significant vegetation is evident along the channel bottoms where the hydraulic radius exceeds 0.61 meters.
Large	0.025-0.050	Turf grass growing where the average depth of flow is about equal to the height of the vegetation; 8-to-10-years-old willow or cottonwood trees intergrown with some weeds and brush (none of the vegetation in foliage) where the hydraulic radius exceeds0.60 m; bushy willows about 1 year old intergrown with some weeds along side slopes (all vegetation in full foliage), and no significant vegetation exists along channel bottoms where the hydraulic radius is greater than 0.61 meters.
Very Large	0.050-0.100	Turf grass growing where the average depth of flow is less than half the height of the vegetation; bushy willow trees about 1 year old intergrown with weeds along side slopes C all vegetation in full foliage), or dense cattails growing along channel bottom; trees intergrow with weeds and brush (all vegetation in full foliage).

(Degree of Meandering m) [1] [2] m

Channel Conditions	*n* Value Adjustment[1]	Example
Minor	1.00	Ratio of the channel length to valley length is 1.0 to 1.2.
Appreciable	1.15	Ratio of the channel length to valley length is 1.2 to 1.5.
Severe	1.30	Ratio of the channel length to valley length is greater than 1.5.

1 Adjustments for degree of irregularity, variation in cross section, effect of obstructions, and vegetation are added to the base *n* value (Table 1) before multiplying by the adjustment for meander.

2 Adjustment values apply to flow confined in channel and do not apply where downvalley flow crosses meanders.

Table 3. Adjustment Values for Factors that Affect the Roughness of a Floodplains.
[modified from Aldridge and Garrett, 1973, Table 2]

Flood-Plain Conditions	n Value Adjustment	Example
		Degree of Irregularity (n_1)
Smooth	0.000	Compares to the smoothest, flattest flood-plain attainable in a given bed material.
Minor	0.001-0.005	Is a Flood Plain Slightly irregular in shape. A few rises and dips or sloughs may be more visible on the flood plain.
Moderate	0.006-0.010	Has more rises and dips. Sloughs and hummocks may occur.
Severe	0.011-0.020	Flood Plain very irregular in shape. Many rises and dips or sloughs are visible. Irregular ground surfaces in pasture land and furrows perpendicular to the flow are also included.

Variation of Flood-Plain cross section (n_2)

Gradual	0.0	Not applicable

Effect of obstruction (n_3)

Negligible	0.000-0.004	Few scattered obstructions, which include debris deposits, stumps, exposed roots, logs, piers, or isolated boulders, that occupy less than 5 percent of the cross-sectional area.
Minor	0.040-0.050	Obstructions occupy less than 15 percent of the cross-sectional area.
Appreciable	0.020-0.030	Obstructions occupy from 15 percent to 50 percent of the cross-sectional area.

Amount of vegetation (n_4)

Small	0.001-0.010	Dense growths of flexible turf grass, such as Bermuda, or weeds growing where the average depth of flow is at least two times the height of the vegetation; supple tree seedlings such as willow, cottonwood, arrow-weed, or saltcedar growing where the average depth of flow is at least three times the height of the vegetation.
Medium	0.010-0.025	Turf grass growing where the average depth of flow is from one to two times the height of the vegetation; moderately dense stemy grass, weeds, or tree seedlings growing where the average depth of flow is from two to three times the height of the vegetation; brushy, moderately dense vegetation, similar to 1-to-2-year-old willow trees in the dormant season..
Large	0.025-0.050	Turf grass growing where the average depth of flow is about equal to the height of the vegetation; 8-to-10-years-old willow or cottonwood trees intergrow with some weeds and brush (none of the vegetation in foliage) where the hydraulic radius exceeds 0.607 m.;or mature row crops such as small vegetables, or mature field crops where depth flow is at least twice the height of the vegetation.
Very Large	0.050-0.100	Turf grass growing where the average depth of flow is less than half the height of the vegetation; or moderate to dense brush, or heavy stand of timber with few down trees and little undergrowth where depth of flow is below branches, or mature field crops where depth of flow is less than the height of the vegetation.
Extreme	0.100-0.200	Dense bushy willow, mesquite, and saltcedar(all vegetation in full foliage), or heavy stand of timber, few down trees, depth of reaching branches.

Degree of Meander(m)

	1.0	Not Applicable

APPENDIX E

FIGURE 01P FROM 1996 FEMA FLOOD INSURANCE STUDY

SR 87 Connector Proposed Bridge Crossings over Clear Creek and Blackwater River

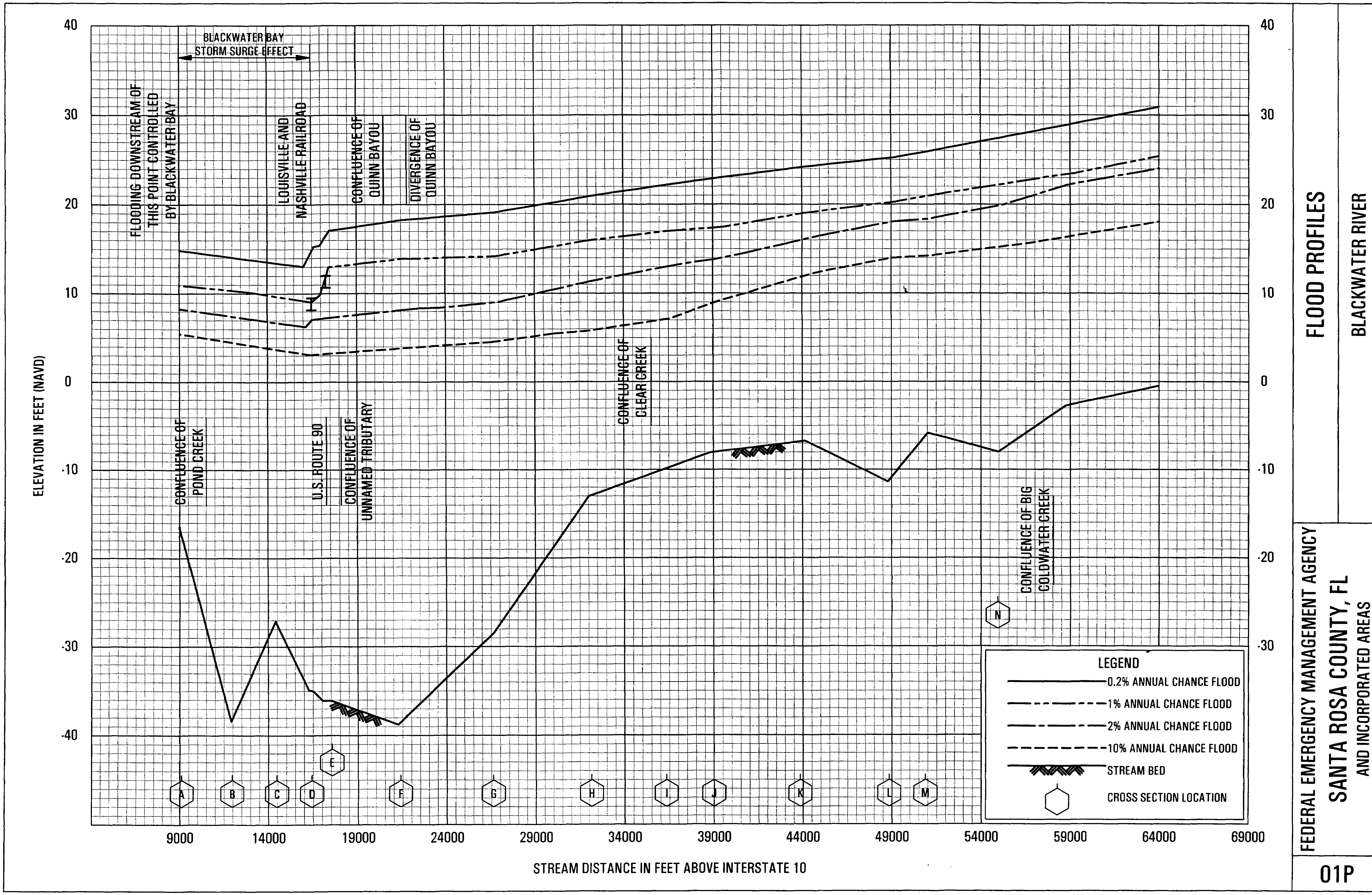
Technical Memorandum

Financial Project ID

416748-3-32-01

Santa Rosa County, Florida

165 Lincoln Avenue
Winter Park, FL 32889
Phone: 407.629.2185
Fax: 407.629.2183
www.balmoralgroup.us



ELEVATION IN FEET (NAVD)
STREAM DISTANCE IN FEET ABOVE INTERSTATE 10
BLACKWATER BAY STORM SURGE EFFECT
FLOODING DOWNSTREAM OF THIS POINT CONTROLLED BY BLACKWATER BAY
LOUISVILLE AND NASHVILLE RAILROAD
CONFLUENCE OF QUINN BAYOU
DIVERGENCE OF QUINN BAYOU
CONFLUENCE OF POND CREEK
U.S. ROUTE 90
CONFLUENCE OF UNNAMED TRIBUTARY
CONFLUENCE OF CLEAR CREEK
CONFLUENCE OF BIG COLDWATER CREEK
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION
FLOOD PROFILES
BLACKWATER RIVER
FEDERAL EMERGENCY MANAGEMENT AGENCY
SANTA ROSA COUNTY, FL
AND INCORPORATED AREAS
01P

APPENDIX F

SOIL BORINGS

SR 87 Connector Proposed Bridge Crossings over Clear Creek and Blackwater River

Technical Memorandum

Financial Project ID

416748-3-32-01

Santa Rosa County, Florida

165 Lincoln Avenue
Winter Park, FL 32889
Phone: 407.629.2185
Fax: 407.629.2183
www.balmoralgroup.us

NOTES

1. NUMBERS LEFT OF BORINGS INDICATE STANDARD PENETRATION TEST (SPT) N-VALUES FOR 12 IN. PENETRATION (UNLESS OTHERWISE NOTED)
2. WATER ELEVATIONS SHOWN ARE THE WATER ELEVATIONS ENCOUNTERED. FLUCATIONS IN THE ELEVATION OF WATER SHOULD BE EXPECTED.
3. SOIL DESCRIPTIONS, TEST DATA, AND STANDARD PENETRATION VALUES SHOWN ARE FOR THE SOIL BORING ONLY AND MAY NOT APPLY TO ANY OTHER LOCATIONS EXCEPT AT THE LOCATION OF THE SOIL BORING. EXTRAPOLATION OF THE SOIL BORING DATA TO OTHER LOCATIONS IS THE SOLE RESPONSIBILITY OF THE PERSON PERFORMING THE EXTRAPOLATION.

GRANULAR MATERIALS RELATIVE DENSITY	SPT (BLOWS/12 IN.)	SILTS AND CLAYS CONSISTENCY	SPT (BLOWS/12 IN.)
VERY LOOSE	LESS THAN 3	VERY SOFT	LESS THAN 1
LOOSE	3 - 8	SOFT	1 - 3
MEDIUM DENSE	8 - 24	FIRM	3 - 6
DENSE	24 - 40	STIFF	6 - 12
VERY DENSE	GREATER THAN 40	VERY STIFF	12 - 24
		HARD	GREATER THAN 24

SPLIT-SPOON: INSIDE DIAMETER: 1.375 IN
OUTSIDE DIAMETER: 2.0 IN
AVG. HAMMER DROP: 30.0 IN
HAMMER WEIGHT: 140 LBS

LEGEND

MEASURED GROUNDWATER

LABORATORY TESTING RESULTS

WATER CONTENT (%) Wc=
-200 SIEVE (%) -200=
LIQUID LIMIT LL=
PLASTICITY INDEX PI=

(SM) UNIFIED SOIL CLASSIFICATION GROUP SYMBOL

MEDIUM TO FINE SAND (SP-SM)

SILTY MEDIUM TO SILTY FINE SAND (SM)

SAND AND FIBROUS ORGANICS

CLAYEY SAND (SC)

ENVIRONMENTAL CLASSIFICATION

SUPERSTRUCTURE: SLIGHTLY AGGRESSIVE
SUBSTRUCTURE: MODERATELY AGGRESSIVE FOR STEEL (pH 6.2)
MODERATELY AGGRESSIVE FOR CONCRETE

REVISIONS					
DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

DERWOOD C. SHEPPARD, P.E. P.E. NO.: 69228
Environmental & Geotechnical Specialists, Inc.
EGS
3154 Eliza Road
Tallahassee, Florida 32308
Office : (850) 386-1253
Fax : (850) 385-8050
Certificate of Authorization: 6222

DRAWN BY: AMR 11-11
CHECKED BY: KJC 11-11
DESIGNED BY: DCS 11-11
CHECKED BY: MLH 11-11

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
SR 87	SANTA ROSA	416748-3-22-01

SHEET TITLE: REPORT OF CORE BORINGS

PROJECT NAME: SR 87 CONNECTOR PD&E STUDY

REF. DWG. NO.

SHEET NO.

$USER$ $DATE$ $TIME$ $FILE$

NOTES

1. NUMBERS LEFT OF THE BORING INDICATE STANDARD PENETRATION TEST (SPT) N-VALUES FOR 12 IN. PENETRATION (UNLESS OTHERWISE NOTED)

2. WATER ELEVATION SHOWN IS THE WATER ELEVATION ENCOUNTERED. FLUCTUATIONS IN THE ELEVATION OF WATER SHOULD BE EXPECTED.

3. SOIL DESCRIPTIONS, TEST DATA, AND STANDARD PENETRATION VALUES SHOWN ARE FOR THE SOIL BORING ONLY AND MAY NOT APPLY TO ANY OTHER LOCATIONS EXCEPT AT THE LOCATION OF THE SOIL BORING. EXTRAPOLATION OF THE SOIL BORING DATA TO OTHER LOCATIONS IS THE SOLE RESPONSIBILITY OF THE PERSON PERFORMING THE EXTRAPOLATION.

SPLIT-SPOON:
INSIDE DIAMETER: 1.375 in.
OUTSIDE DIAMETER: 2.0 in.
AVG. HAMMER DROP: 30.0 in.
HAMMER WEIGHT: 140 lbs.

Granular Materials Relative Density	SPT (blows/12 in.)	Silts and Clays Consistency	SPT (blows/12 in.)
Very Loose	Less than 3	Very Soft	Less than 1
Loose	3 - 8	Soft	1 - 3
Medium Dense	8 - 24	Firm	3 - 6
Dense	24 - 40	Stiff	6 - 12
Very Dense	Greater than 40	Very Stiff	12 - 24
		Hard	Greater than 24

LEGEND

MEASURED GROUNDWATER ▼

LABORATORY TESTING RESULTS

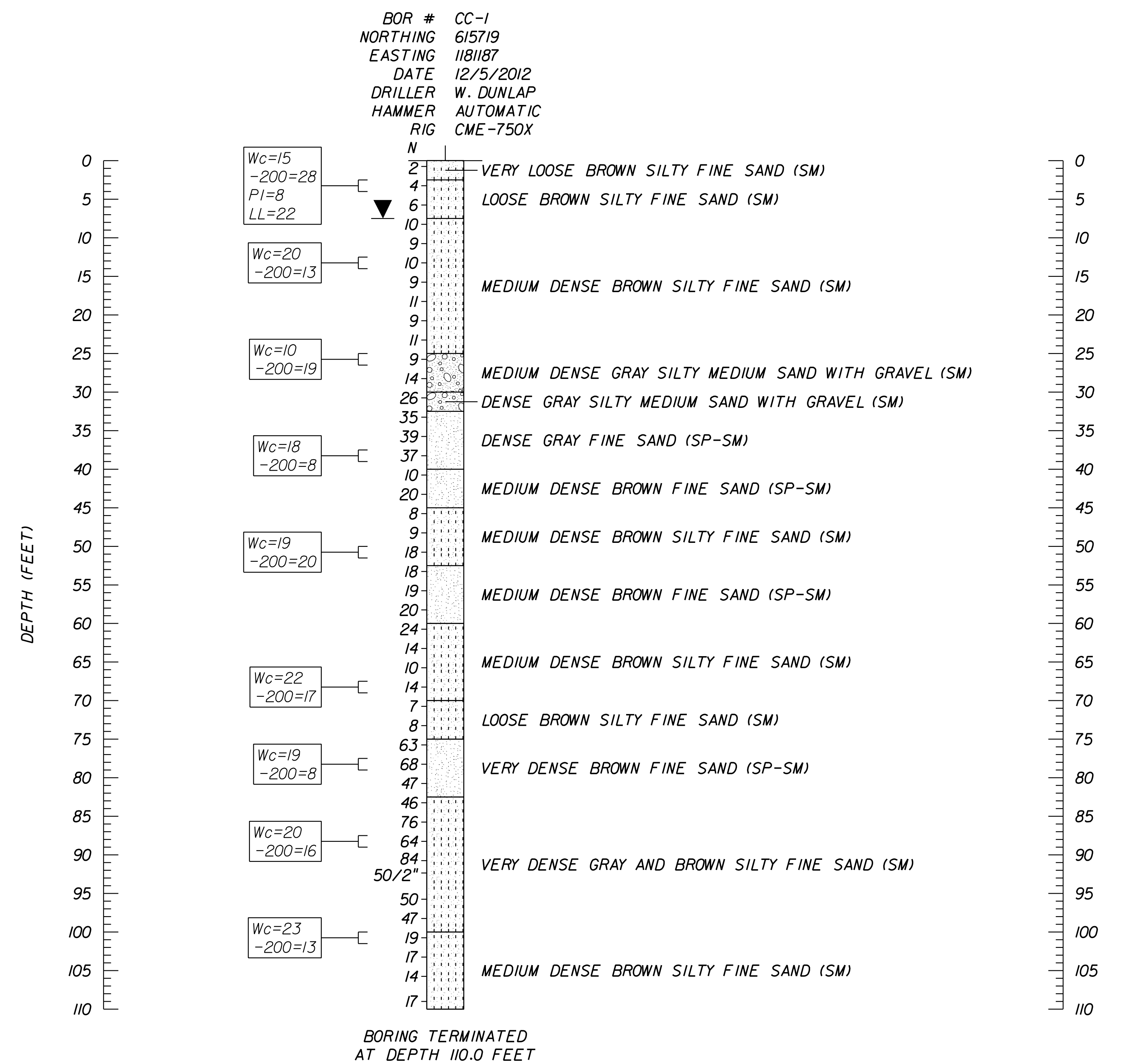
WATER CONTENT Wc=
-200 SIEVE -200=
LIQUID LIMIT LL=
PLASTIC INDEX PI=

(SM) UNIFIED SOIL CLASSIFICATION GROUP SYMBOL

FINE SAND (SP-SM)

SILTY MEDIUM SAND WITH GRAVEL (SM)

SILTY FINE SAND (SM)



ENVIRONMENTAL CLASSIFICATION

SUPERSTRUCTURE: SLIGHTLY AGGRESSIVE FOR STEEL
SLIGHTLY AGGRESSIVE FOR CONCRETE

SUBSTRUCTURE: EXTREMELY AGGRESSIVE FOR STEEL (pH = 5.5)
MODERATELY AGGRESSIVE FOR CONCRETE

REVISIONS

DATE	BY	DESCRIPTION	DATE	BY	DESCRIPTION

DERWOOD C. SHEPPARD, P.E. P.E. NO.: 69228
Environmental & Geotechnical Specialists, Inc.
EGS
104 North Magnolia Drive
Tallahassee, Florida 32301
Office : (850) 386-1253
Fax : (850) 385-8050
Certificate of Authorization: 6222

DRAWN BY: ZLB 12-12
CHECKED BY: EHJ 12-12
DESIGNED BY: DCS 12-12
CHECKED BY: DCS 12-12

STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

ROAD NO.	COUNTY	FINANCIAL PROJECT ID
SR 87	SANTA ROSA	416748-3-22-01

SHEET TITLE: REPORT OF CORE BORING

PROJECT NAME: SR 87 OVER CLEAR CREEK CONNECTOR BRIDGE

REF. DWG. NO.

SHEET NO.

EGSSTUDENT 12/17/2012 8:30:08 AM J:\EGS Projects\EGS Projects\(70) - FDOT\(111) - SR 87 Connector Bridge\41674832201\geotech\E